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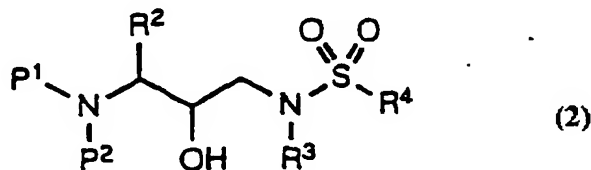
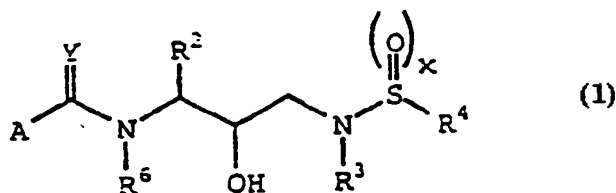
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(21) International Application Number: PCT/US94/09139 (22) International Filing Date: 23 August 1994 (23.08.94) (30) Priority Data: 08/110,911 24 August 1993 (24.08.93) US 08/204,827 2 March 1994 (02.03.94) US (60) Parent Applications or Grants (63) Related by Continuation US 08/110,911 (CON) Filed on 24 August 1993 (24.08.93) US 08/204,827 (CON) Filed on 2 March 1994 (02.03.94) (71) Applicants (for all designated States except US): G.D. SEARLE & CO. [US/US]; Corporate Patent Dept., P.O. Box 5110, Chicago, IL 60680-5110 (US). THE MONSANTO COMPANY [US/US]; 800 North Lindbergh Boulevard, St. Louis, MO 63167 (US). (72) Inventors; and (75) Inventors/Applicants (for US only): VAZQUEZ, Michael, L. [US/US]; 233 Saratoga Court, Gurnee, IL 60031 (US).		MUELLER, Richard, A. [US/US]; 562 Stonegate Terrace, Glencoe, IL 60022 (US). TALLEY, John, J. [US/US]; 8772 Pine Avenue, Brentwood, MO 63144 (US). GETMAN, Daniel, P. [US/US]; 66 Sunny Hill Court, Chesterfield, MO 63017 (US). DECRESCENZO, Gary, A. [US/US]; 536 Schrader Farm Drive, St. Peters, MO 63376 (US). FRESKOS, John, N. [US/US]; 7572 York, Clayton, MO 63105 (US). BERTENSHAW, Deborah, E. [US/US]; 8758 Pine Avenue, Brentwood, MO 63144 (US). HEINTZ, Robert, M. [US/US]; 603 Nancy Place, Ballwin, MO 63021 (US). (74) Agents: UNGEMACH, Frank, S. et al.; G.D. Searle & Co., Corporate Patent Dept., P.O. Box 5110, Chicago, IL 60680-5110 (US). (81) Designated States: AM, AT, AU, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, ES, FI, GB, GE, HU, JP, KE, KG, KP, KR, KZ, LK, LT, LU, LV, MD, MG, MN, MW, NL, NO, NZ, PL, PT, RO, RU, SD, SE, SI, SK, TJ, TT, UA, US, UZ, VN, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG), ARIPO patent (KE, MW, SD). Published With international search report.	

(54) Title: **HYDROXYETHYLAMINO SULPHONAMIDES USEFUL AS RETROVIRAL PROTEASE INHIBITORS**

(57) Abstract

Hydroxyethylamino sulphonamide compounds of formulae (1) and (2), wherein A, R², R³, R⁴, R⁶, x, P¹ and P² are as defined in claims 1 and 8 are effective as retroviral protease inhibitors, and in particular as inhibitors of HIV protease.



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Hydroxyethylamino sulphonamides useful as retroviral protease inhibitors

RELATED APPLICATION

5 This application is a continuation in part application of co-owned and co-pending U.S. patent application Serial No. 08/204,827 filed March 2, 1994, which is a continuation in part application of co-owned and co-pending PCT/US93/07814, filed August 24, 1993,
10 which is a continuation in part application of co-owned U.S. patent application Serial No. 07/934,984 filed August 25, 1992, now abandoned, each of which is incorporated herein by reference in its entirety.

BACKGROUND OF THE INVENTION

1. Field of the Invention

 The present invention relates to retroviral protease inhibitors and, more particularly, relates to
20 novel compounds and a composition and method for inhibiting retroviral proteases. This invention, in particular, relates to sulfonamide-containing hydroxyethylamine protease inhibitor compounds, a composition and method for inhibiting retroviral
25 proteases such as human immunodeficiency virus (HIV) protease and for treating a retroviral infection, e.g., an HIV infection. The subject invention also relates to processes for making such compounds as well as to intermediates useful in such processes.

2. Related Art

 During the replication cycle of retroviruses, gag and gag-pol gene transcription products are translated as proteins. These proteins are subsequently processed by
35 a virally encoded protease (or proteinase) to yield viral enzymes and structural proteins of the virus core. Most commonly, the gag precursor proteins are processed into

the core proteins and the pol precursor proteins are processed into the viral enzymes, e.g., reverse transcriptase and retroviral protease. It has been shown that correct processing of the precursor proteins by the retroviral protease is necessary for assembly of infectious virions. For example, it has been shown that frameshift mutations in the protease region of the pol gene of HIV prevents processing of the gag precursor protein. It has also been shown through site-directed mutagenesis of an aspartic acid residue in the HIV protease active site that processing of the gag precursor protein is prevented. Thus, attempts have been made to inhibit viral replication by inhibiting the action of retroviral proteases.

Retroviral protease inhibition typically involves a transition-state mimetic whereby the retroviral protease is exposed to a mimetic compound which binds (typically in a reversible manner) to the enzyme in competition with the gag and gag-pol proteins to thereby inhibit specific processing of structural proteins and the release of retroviral protease itself. In this manner, retroviral replication proteases can be effectively inhibited.

Several classes of compounds have been proposed, particularly for inhibition of proteases, such as for inhibition of HIV protease. Such compounds include hydroxyethylamine isosteres and reduced amide isosteres. See, for example, EP O 346 847; EP O 342,541; Roberts et al, "Rational Design of Peptide-Based Proteinase Inhibitors, "Science, 248, 358 (1990); and Erickson et al, "Design Activity, and 2.8Å Crystal Structure of a C₂ Symmetric Inhibitor Complexed to HIV-1 Protease," Science, 249, 527 (1990).

Several classes of compounds are known to be useful as inhibitors of the proteolytic enzyme renin.

See, for example, U.S. No. 4,599,198; U.K. 2,184,730;

G.B. 2,209,752; EP O 264 795; G.B. 2,200,115 and U.S. SIR

5 H725. Of these, G.B. 2,200,115, GB 2,209,752, EP O

264,795, U.S. SIR H725 and U.S. 4,599,198 disclose urea-containing hydroxyethylamine renin inhibitors. EP 468

641 discloses renin inhibitors and intermediates for the preparation of the inhibitors, which include sulfonamide-

10 containing hydroxyethylamine compounds, such as 3-(t-butoxycarbonyl)amino-cyclohexyl-1-(phenylsulfonyl)amino-2(5)-butanol. G.B. 2,200,115 also discloses sulfamoyl-

containing hydroxyethylamine renin inhibitors, and EP 0264 795 discloses certain sulfonamide-containing

15 hydroxyethylamine renin inhibitors. However, it is known that, although renin and HIV proteases are both classified as aspartyl proteases, compounds which are effective renin inhibitors generally cannot be predicted to be effective HIV protease inhibitors.

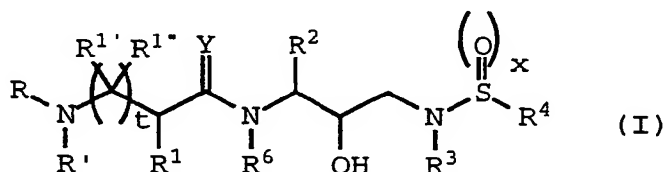
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BRIEF DESCRIPTION OF THE INVENTION

The present invention is directed to virus
25 inhibiting compounds and compositions. More particularly, the present invention is directed to retroviral protease inhibiting compounds and compositions, to a method of inhibiting retroviral proteases, to processes for preparing the compounds and
30 to intermediates useful in such processes. The subject compounds are characterized as sulfonamide-containing hydroxyethylamine inhibitor compounds.

DETAILED DESCRIPTION OF THE INVENTION

In accordance with the present invention, there is provided a retroviral protease inhibiting compound of the formula:



or a pharmaceutically acceptable salt, prodrug or ester
10 thereof, wherein:

R represents hydrogen, alkoxycarbonyl, aralkoxycarbonyl, alkylcarbonyl, cycloalkylcarbonyl, cycloalkylalkoxycarbonyl, cycloalkylalkanoyl, alkanoyl, aralkanoyl, aroyl, aryloxycarbonyl, aryloxycarbonylalkyl, aryloxyalkanoyl, heterocyclylcarbonyl, heterocyclyloxycarbonyl, heterocyclylalkanoyl, heterocyclylalkoxycarbonyl, heteroaralkanoyl, heteroaralkoxycarbonyl, heteroaryloxycarbonyl, heteroaroyl, alkyl, alkenyl, alkynyl, cycloalkyl, aryl, aralkyl, aryloxyalkyl, heteroaryloxyalkyl, hydroxyalkyl, aminocarbonyl, aminoalkanoyl, and mono- and disubstituted aminocarbonyl and mono- and disubstituted aminoalkanoyl radicals wherein the substituents are selected from alkyl, aryl, aralkyl, cycloalkyl, cycloalkylalkyl, heteroaryl, heteroaralkyl, heterocycloalkyl, heterocycloalkylalkyl radicals, or where said aminocarbonyl and aminoalkanoyl radicals are disubstituted, said substituents along with the nitrogen atom to which they are attached form a heterocycloalkyl or heteroaryl radical;

R' represents hydrogen, radicals as defined for R³ or RⁿSO₂- wherein Rⁿ represents radicals as defined for R³;

or R and R' together with the nitrogen to which they are attached represent heterocycloalkyl and heteroaryl radicals;

- 5 R¹ represents hydrogen, -CH₂SO₂NH₂, -CH₂CO₂CH₃, -CO₂CH₃, -CONH₂, -CH₂C(O)NHCH₃, -C(CH₃)₂(SH), -C(CH₃)₂(SCH₃), -C(CH₃)₂(S[O]CH₃), -C(CH₃)₂(S[O]₂CH₃), alkyl, haloalkyl, alkenyl, alkynyl and cycloalkyl radicals, and amino acid side chains selected from asparagine, S-methyl cysteine
10 and the sulfoxide (SO) and sulfone (SO₂) derivatives thereof, isoleucine, allo-isoleucine, alanine, leucine, tert-leucine, phenylalanine, ornithine, histidine, norleucine, glutamine, threonine, allo-threonine, serine, O-alkyl serine, aspartic acid, beta-cyano alanine and
15 valine side chains;

- R^{1'} and R^{1''} independently represent hydrogen and radicals as defined for R¹, or one of R^{1'} and R^{1''}, together with R¹ and the carbon atoms to which R¹, R^{1'} and R^{1''} are
20 attached, represent a cycloalkyl radical;

- R² represents alkyl, aryl, cycloalkyl, cycloalkylalkyl and aralkyl radicals, which radicals are optionally substituted with a group selected from alkyl and halogen
25 radicals, -NO₂, -CN, -CF₃, -OR⁹ and -SR⁹, wherein R⁹ represents hydrogen and alkyl radicals, and halogen radicals;

- R³ represents hydrogen, alkyl, haloalkyl, alkenyl, alkynyl, hydroxyalkyl, alkoxyalkyl, cycloalkyl, cycloalkylalkyl, heterocycloalkyl, heteroaryl, heterocycloalkylalkyl, aryl, aralkyl, heteroaralkyl, aminoalkyl and mono- and disubstituted aminoalkyl radicals, wherein said substituents are selected from
30 alkyl, aryl, aralkyl, cycloalkyl, cycloalkylalkyl, heteroaryl, heteroaralkyl, heterocycloalkyl, and heterocycloalkylalkyl radicals, or in the case of a

disubstituted aminoalkyl radical, said substituents along with the nitrogen atom to which they are attached, form a heterocycloalkyl or a heteroaryl radical;

5 R^4 represents radicals as defined by R^3 except for hydrogen;

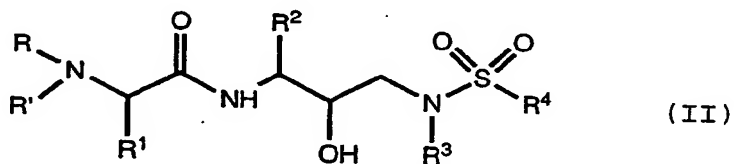
R^6 represents hydrogen and alkyl radicals;

10 x represents 0, 1 or 2;

t represents either 0 or 1; and

15 Y represents O, S and NR^{15} wherein R^{15} represents hydrogen and radicals as defined for R^3 .

A family of compounds of particular interest within Formula I are compounds embraced by Formula II:



wherein:

25 R represents hydrogen, alkoxycarbonyl, aralkoxycarbonyl, alkylcarbonyl, cycloalkylcarbonyl, cycloalkylalkoxycarbonyl, cycloalkylalkanoyl, alkanoyl, aralkanoyl, aroyl, aryloxycarbonyl, aryloxycarbonylalkyl, aryloxyalkanoyl, heterocyclylcarbonyl, heterocyclyloxycarbonyl, heterocyclylalkanoyl, 30 heterocyclylalkoxycarbonyl, heteroaralkanoyl, heteroaralkoxycarbonyl, heteroaryloxy-carbonyl, heteroaroyl, alkyl, alkenyl, cycloalkyl, aryl, aralkyl, aryloxyalkyl, heteroaryloxyalkyl, hydroxyalkyl, aminocarbonyl, aminoalkanoyl, and mono- and disubstituted

- aminocarbonyl and mono- and disubstituted aminoalkanoyl radicals wherein the substituents are selected from alkyl, aryl, aralkyl, cycloalkyl, cycloalkylalkyl, heteroaryl, heteroaralkyl, heterocycloalkyl,
- 5 heterocycloalkyl radicals, or where said aminoalkanoyl radical is disubstituted, said substituents along with the nitrogen atom to which they are attached form a heterocycloalkyl or heteroaryl radical;
- 10 R' represents hydrogen and radicals as defined for R³ or R and R' together with the nitrogen to which they are attached represent heterocycloalkyl and heteroaryl radical;
- 15 R¹ represents hydrogen, -CH₂SO₂NH₂, -CH₂CO₂CH₃, -CO₂CH₃, -CONH₂, -CH₂C(O)NHCH₃, -C(CH₃)₂(SH), -C(CH₃)₂(SCH₃), -C(CH₃)₂(S[O]CH₃), -C(CH₃)₂(S[O]₂CH₃), alkyl, haloalkyl, alkenyl, alkynyl and cycloalkyl radicals, and amino acid side chains selected from asparagine, S-methyl cysteine
- 20 and the sulfoxide (SO) and sulfone (SO₂) derivatives thereof, isoleucine, allo-isoleucine, alanine, leucine, tert-leucine, phenylalanine, ornithine, histidine, norleucine, glutamine, threonine, allo-threonine, serine, O-methyl serine, aspartic acid, beta-cyano alanine and
- 25 valine side chains;
- R² represents alkyl, aryl, cycloalkyl, cycloalkylalkyl and aralkyl radicals, which radicals are optionally substituted with a group selected from alkyl and halogen
- 30 radicals, -NO₂, -C≡N, CF₃, -OR⁹, -SR⁹, wherein R⁹ represents hydrogen and alkyl radicals;
- R³ represents alkyl, haloalkyl, alkenyl, alkynyl, hydroxyalkyl, alkoxyalkyl, cycloalkyl, cycloalkylalkyl,
- 35 heterocycloalkyl, heteroaryl, heterocycloalkylalkyl, aryl, aralkyl, heteroaralkyl, aminoalkyl and mono- and disubstituted aminoalkyl radicals, wherein said

substituents are selected from alkyl, aryl, aralkyl, cycloalkyl, cycloalkylalkyl, heteroaryl, heteroaralkyl, heterocycloalkyl, and heterocycloalkylalkyl radicals, or in the case of a disubstituted aminoalkyl radical, said substituents along with the nitrogen atom to which they are attached, form a heterocycloalkyl or a heteroaryl radical; and

R⁴ represents radicals as defined by R³.

10

A more preferred family of compounds within Formula II consists of compounds wherein:

R represents hydrogen, alkoxycarbonyl, aralkoxycarbonyl, alkylcarbonyl, cycloalkylcarbonyl, cycloalkylalkoxycarbonyl, cycloalkylalkanoyl, alkanoyl, aralkanoyl, aroyl, aryloxycarbonyl, aryloxycarbonylalkyl, aryloxyalkanoyl, heterocyclylcarbonyl, heterocyclyloxycarbonyl, heterocyclylalkanoyl, heterocyclylalkoxycarbonyl, heteroaralkanoyl, heteroaralkoxycarbonyl, heteroaryloxy-carbonyl, heteroaroyl, alkyl, alkenyl, cycloalkyl, aryl, aralkyl, aryloxyalkyl, heteroaryloxyalkyl, hydroxyalkyl, aminocarbonyl, aminoalkanoyl, and mono- and disubstituted aminocarbonyl and mono- and disubstituted aminoalkanoyl radicals wherein the substituents are selected from alkyl, aryl, aralkyl, cycloalkyl, cycloalkylalkyl, heteroaryl, heteroaralkyl, heterocycloalkyl, heterocycloalkylalkyl radicals, or where said aminoalkanoyl radical is disubstituted, said substituents along with the nitrogen atom to which they are attached form a heterocycloalkyl or heteroaryl radical;

R' represents hydrogen and radicals as defined for R³ or R and R' together with the nitrogen to which they are attached represent heterocycloalkyl and heteroaryl radical;

- R¹ represents CH₂C(O)NHCH₃, C(CH₃)₂(SCH₃), C(CH₃)₂(S[O]CH₃), C(CH₃)₂(S[O]₂CH₃), alkyl, alkenyl and alkynyl radicals, and amino acid side chains selected from the group consisting of asparagine, valine, threonine, allo-threonine, isoleucine, tert-leucine, S-methyl cysteine and the sulfone and sulfoxide derivatives thereof, alanine, and allo-isoleucine;
- R² represents alkyl, cycloalkylalkyl and aralkyl radicals, which radicals are optionally substituted with halogen radicals and radicals represented by the formula -OR⁹ and -SR⁹ wherein R⁹ represents alkyl radicals; and
- R³ and R⁴ independently represent alkyl, alkenyl, alkoxyalkyl, cycloalkyl, cycloalkylalkyl, heterocycloalkyl, heterocycloalkylalkyl, aryl, aralkyl and heteroaralkyl radicals.
- Of highest interest are compounds within Formula II wherein
- R represents alkoxycarbonyl, aralkoxycarbonyl, alkylcarbonyl, cycloalkylcarbonyl, cycloalkylalkoxycarbonyl, cycloalkylalkanoyl, alkanoyl, aralkanoyl, aroyl, aryloxycarbonyl, aryloxycarbonylalkyl, aryloxyalkanoyl, heterocyclylcarbonyl, heterocyclyloxycarbonyl, heterocyclylalkanoyl, heterocyclylalkoxycarbonyl, heteroaralkanoyl, heteroaralkoxycarbonyl, heteroaryloxy-carbonyl, heteroaroyl, aminocarbonyl, aminoalkanoyl, and mono- and disubstituted aminocarbonyl and mono- and disubstituted aminoalkanoyl radicals wherein the substituents are selected from alkyl, aryl, aralkyl, cycloalkyl, cycloalkylalkyl, heteroaryl, heteroaralkyl, heterocycloalkyl, heterocycloalkylalkyl radicals, or where said aminoalkanoyl radical is disubstituted, said

substituents along with the nitrogen atom to which they are attached form a heterocycloalkyl or heteroaryl radical;

- 5 R' represents hydrogen and radicals as defined for R³ or R and R' together with the nitrogen to which they are attached represent heterocycloalkyl and heteroaryl radical;
- 10 R¹ represents CH₂C(O)NHCH₃, C(CH₃)₂(SCH₃), C(CH₃)₂(S[O]CH₃), C(CH₃)₂(S[O]₂CH₃), methyl, propargyl, t-butyl, isopropyl and sec-butyl radicals, and amino acid side chains selected from the group consisting of asparagine, valine, S-methyl cysteine, allo-iso-leucine, iso-leucine, and beta-cyano alanine side chains;
- 15

R² represents CH₃SCH₂CH₂-, iso-butyl, n-butyl, benzyl, 4-fluorobenzyl, 2-naphthylmethyl and cyclohexylmethyl radicals;

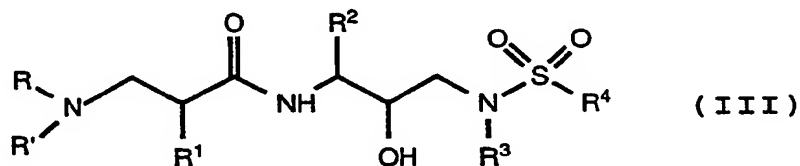
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R³ represents isoamyl, n-butyl, isobutyl and cyclohexyl radicals; and

25 R⁴ represents phenyl, substituted phenyl and methyl radicals.

Another family of compounds of particular interest within Formula I are compounds embraced by Formula III:

30



wherein:

R represents hydrogen, alkoxycarbonyl, aralkoxycarbonyl, alkylcarbonyl, cycloalkylcarbonyl,

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cycloalkylalkoxycarbonyl, cycloalkylalkanoyl, alkanoyl, aralkanoyl, aroyl, aryloxycarbonyl, aryloxycarbonylalkyl, aryloxyalkanoyl, heterocyclylcarbonyl, heterocyclyloxycarbonyl, heterocyclylalkanoyl, heterocyclylalkoxycarbonyl, heteroaralkanoyl, heteroaralkoxycarbonyl, heteroaryloxy-carbonyl, heteroaroyl, alkyl, alkenyl, cycloalkyl, aryl, aralkyl, aryloxyalkyl, heteroaryloxyalkyl, hydroxyalkyl, aminocarbonyl, aminoalkanoyl, and mono- and disubstituted aminocarbonyl and mono- and disubstituted aminoalkanoyl radicals wherein the substituents are selected from alkyl, aryl, aralkyl, cycloalkyl, cycloalkylalkyl, heteroaryl, heteroaralkyl, heterocycloalkyl, heterocycloalkylalkyl radicals, or where said aminoalkanoyl radical is disubstituted, said substituents along with the nitrogen atom to which they are attached form a heterocycloalkyl or heteroaryl radical;

R' represents hydrogen and radicals as defined for R³ or R and R' together with the nitrogen to which they are attached represent heterocycloalkyl and heteroaryl radical;

R¹ represents hydrogen, -CH₂SO₂NH₂, -CH₂CO₂CH₃, -CO₂CH₃, -CONH₂, -CH₂C(O)NHCH₃, -C(CH₃)₂(SH), -C(CH₃)₂(SCH₃), -C(CH₃)₂(S[O]CH₃), -C(CH₃)₂(S[O]₂CH₃), alkyl, haloalkyl, alkenyl, alkynyl and cycloalkyl radicals, and amino acid side chains selected from asparagine, S-methyl cysteine and the sulfoxide (SO) and sulfone (SO₂) derivatives thereof, isoleucine, allo-isoleucine, alanine, leucine, tert-leucine, phenylalanine, ornithine, histidine, norleucine, glutamine, threonine, allo-threonine, serine, aspartic acid, beta-cyano alanine and valine side chains;

35

R² represents alkyl, aryl, cycloalkyl, cycloalkylalkyl and aralkyl radicals, which radicals are optionally

substituted with a group selected from alkyl and halogen radicals, $-\text{NO}_2$, $-\text{C}\equiv\text{N}$, CF_3 , $-\text{OR}^9$, $-\text{SR}^9$, wherein R^9 represents hydrogen and alkyl;

- 5 R^3 represents alkyl, haloalkyl, alkenyl, alkynyl, hydroxyalkyl, alkoxyalkyl, cycloalkyl, cycloalkylalkyl, heterocycloalkyl, heteroaryl, heterocycloalkylalkyl, aryl, aralkyl, heteroaralkyl, aminoalkyl and mono- and disubstituted aminoalkyl radicals, wherein said
- 10 substituents are selected from alkyl, aryl, aralkyl, cycloalkyl, cycloalkylalkyl, heteroaryl, heteroaralkyl, heterocycloalkyl, and heterocycloalkylalkyl radicals, or in the case of a disubstituted aminoalkyl radical, said substituents along with the nitrogen atom to which they
- 15 are attached, form a heterocycloalkyl or a heteroaryl radical; and

R^4 represents radicals as defined by R^3 .

- 20 A more preferred family of compounds within Formula III consists of compounds wherein

R represents hydrogen, alkoxycarbonyl, aralkoxycarbonyl, alkylcarbonyl, cycloalkylcarbonyl,

25 cycloalkylalkoxycarbonyl, cycloalkylalkanoyl, alkanoyl, aralkanoyl, aroyl, aryloxy carbonyl, aryloxy carbonylalkyl, aryloxyalkanoyl, heterocyclylcarbonyl, heterocyclyloxy carbonyl, heterocyclylalkanoyl, heterocyclylalkoxycarbonyl, heteroaralkanoyl,

30 heteroaralkoxycarbonyl, heteroaryloxy-carbonyl, heteroaroyl, alkyl, alkenyl, cycloalkyl, aryl, aralkyl, aryloxyalkyl, heteroaryloxyalkyl, hydroxyalkyl, aminocarbonyl, aminoalkanoyl, and mono- and disubstituted aminocarbonyl and mono- and disubstituted aminoalkanoyl

35 radicals wherein the substituents are selected from alkyl, aryl, aralkyl, cycloalkyl, cycloalkylalkyl, heteroaryl, heteroaralkyl, heterocycloalkyl,

13.

heterocycloalkyl radicals, or where said aminoalkanoyl radical is disubstituted, said substituents along with the nitrogen atom to which they are attached form a heterocycloalkyl or heteroaryl radical;

5

R' represents hydrogen and radicals as defined for R³ or R and R' together with the nitrogen to which they are attached represent heterocycloalkyl and heteroaryl radical;

10

R¹ represents hydrogen, alkyl and alkenyl radicals, and amino acid side chains selected from the group consisting of asparagine, valine, threonine, allo-threonine, isoleucine, tert-leucine, S-methyl cysteine and the sulfone and sulfoxide derivatives thereof, alanine, and allo-isoleucine;

15

R² represents alkyl, cycloalkylalkyl and aralkyl radicals, which radicals are optionally substituted with halogen radicals and radicals represented by the formula -OR⁹ and -SR⁹ wherein R⁹ represents hydrogen and alkyl and halogen radicals; and

20

R³ and R⁴ independently represent alkyl, alkenyl, alkoxyalkyl, cycloalkyl, cycloalkylalkyl, heterocycloalkyl, heterocycloalkylalkyl, aryl, aralkyl, heteroaryl and heteroaralkyl radicals.

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Of highest interest are compounds within

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Formula III wherein

R represents hydrogen, alkoxycarbonyl, aralkoxycarbonyl, alkylcarbonyl, cycloalkylcarbonyl, cycloalkylalkoxycarbonyl, cycloalkylalkanoyl, alkanoyl, aralkanoyl, aroyl, aryloxycarbonyl, aryloxycarbonylalkyl, aryloxyalkanoyl, heterocyclylcarbonyl, heterocyclyloxycarbonyl, heterocyclylalkanoyl,

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heterocyclylalkoxycarbonyl, heteroaralkanoyl,
heteroaralkoxycarbonyl, heteroaryloxy-carbonyl,
heteroaroyl, aminocarbonyl, aminoalkanoyl, and mono- and
disubstituted aminocarbonyl and mono- and disubstituted
5 aminoalkanoyl radicals wherein the substituents are
selected from alkyl, aryl, aralkyl, cycloalkyl,
cycloalkylalkyl, heteroaryl, heteroaralkyl,
heterocycloalkyl, heterocycloalkyl radicals, or where
said aminoalkanoyl radical is disubstituted, said
10 substituents along with the nitrogen atom to which they
are attached form a heterocycloalkyl or heteroaryl
radical;

R' represents hydrogen and radicals as defined for R³ or
15 R and R' together with the nitrogen to which they are
attached represent heterocycloalkyl and heteroaryl
radical;

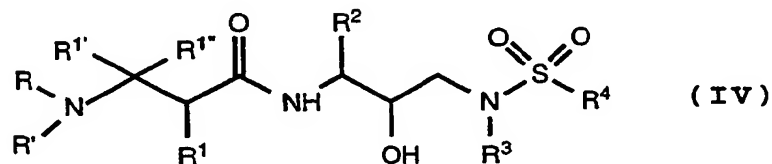
R¹ represents hydrogen, methyl, propargyl, t-butyl,
20 isopropyl and sec-butyl radicals, and amino acid side
chains selected from the group consisting of asparagine,
valine, S-methyl cysteine, allo-iso-leucine, iso-leucine,
threonine, serine, aspartic acid, beta-cyano alanine, and
allo-threonine side chains;

25 R² represents CH₃SCH₂CH₂-, iso-butyl, n-butyl, benzyl,
4-fluorobenzyl, 2-naphthylmethyl and cyclohexylmethyl
radicals; and

30 R³ represents alkyl, cyclohexyl, isobutyl, isoamyl, and
n-butyl radicals; and

R⁴ represents methyl, phenyl and substituted phenyl
radicals wherein the substituents are selected from halo,
35 alkoxy, hydroxy, nitro and amino substituents.

Another family of compounds of particular interest within Formula I are compounds embraced by Formula IV:



wherein:

R represents hydrogen, alkoxycarbonyl, aralkoxycarbonyl, alkylcarbonyl, cycloalkylcarbonyl, cycloalkylalkoxycarbonyl, cycloalkylalkanoyl, alkanoyl, aralkanoyl, aroyl, aryloxycarbonyl, aryloxycarbonylalkyl, aryloxyalkanoyl, heterocyclylcarbonyl, heterocyclyloxycarbonyl, heterocyclylalkanoyl, heterocyclylalkoxycarbonyl, heteroaralkanoyl, heteroaralkoxycarbonyl, heteroaryloxy-carbonyl, heteroaroyl, alkyl, alkenyl, cycloalkyl, aryl, aralkyl, aryloxyalkyl, heteroaryloxyalkyl, hydroxyalkyl, aminocarbonyl, aminoalkanoyl, and mono- and disubstituted aminocarbonyl and mono- and disubstituted aminoalkanoyl radicals wherein the substituents are selected from alkyl, aryl, aralkyl, cycloalkyl, cycloalkylalkyl, heteroaryl, heteroaralkyl, heterocycloalkyl, heterocycloalkyl radicals, or where said aminoalkanoyl radical is disubstituted, said substituents along with the nitrogen atom to which they are attached form a heterocycloalkyl or heteroaryl radical;

R' represents hydrogen and radicals as defined for R³ or R and R' together with the nitrogen to which they are attached represent heterocycloalkyl and heteroaryl radical;

R¹ represents hydrogen, -CH₂SO₂NH₂, -CH₂CO₂CH₃, -CO₂CH₃, -CONH₂, -CH₂C(O)NHCH₃, -C(CH₃)₂(SH), -C(CH₃)₂(SCH₃), -C(CH₃)₂(S[O]CH₃), -C(CH₃)₂(S[O]₂CH₃), alkyl, haloalkyl,

alkenyl, alkynyl and cycloalkyl radicals, and amino acid side chains selected from asparagine, S-methyl cysteine and the sulfoxide (SO) and sulfone (SO₂) derivatives thereof, isoleucine, allo-isoleucine, alanine, leucine, 5 tert-leucine, phenylalanine, ornithine, histidine, norleucine, glutamine, threonine, allo-threonine, serine, aspartic acid, beta-cyano alanine and valine side chains;

10 R^{1'} and R^{1''} independently represent hydrogen and radicals as defined for R¹, or one of R^{1'} and R^{1''}, together with R¹ and the carbon atoms to which R¹, R^{1'} and R^{1''} are attached, represent a cycloalkyl radical;

15 R² represents alkyl, aryl, cycloalkyl, cycloalkylalkyl and aralkyl radicals, which radicals are optionally substituted with a group selected from alkyl and halogen radicals, -NO₂, -C≡N, CF₃, -OR⁹ and -SR⁹, wherein R⁹ represents hydrogen and alkyl radicals;

20

R³ represents alkyl, haloalkyl, alkenyl, alkynyl, hydroxyalkyl, alkoxyalkyl, cycloalkyl, cycloalkylalkyl, heterocycloalkyl, heteroaryl, heterocycloalkylalkyl, aryl, aralkyl, heteroaralkyl, aminoalkyl and mono- and 25 disubstituted aminoalkyl radicals, wherein said substituents are selected from alkyl, aryl, aralkyl, cycloalkyl, cycloalkylalkyl, heteroaryl, heteroaralkyl, heterocycloalkyl, and heterocycloalkylalkyl radicals, or in the case of a disubstituted aminoalkyl radical, said 30 substituents along with the nitrogen atom to which they are attached, form a heterocycloalkyl or a heteroaryl radical; and

35

R⁴ represents radicals as defined by R³.

A more preferred family of compounds within Formula IV consists of compounds wherein

R represents an arylalkanoyl, heteroaroyl,
aryloxyalkanoyl, aryloxycarbonyl, alkanoyl,
aminocarbonyl, mono-substituted aminoalkanoyl, or
5 disubstituted aminoalkanoyl, or mono-or
dialkylaminocarbonyl radical;

R' represents hydrogen and radicals as defined for R³ or
R and R' together with the nitrogen to which they are
10 attached represent a heterocycloalkyl or heteroaryl
radical;

R¹, R^{1'} and R^{1''} independently represent hydrogen and
alkyl radicals having from 1 to about 4 carbon atoms,
15 alkenyl, alkynyl, aralkyl radicals, and radicals
represented by the formula -CH₂C(O)R" or -C(O)R" wherein
R" represents R³⁸, -NR³⁸R³⁹ and OR³⁸ wherein R³⁸ and R³⁹
independently represent hydrogen and alkyl radicals
having from 1 to about 4 carbon atoms;

20 R² represents alkyl, cycloalkylalkyl and aralkyl
radicals, which radicals are optionally substituted with
halogen radicals and radicals represented by the formula
-OR⁹ and -SR⁹ wherein R⁹ represents hydrogen and alkyl
25 radicals; and

R³ and R⁴ independently represent alkyl, alkenyl,
alkoxyalkyl, cycloalkyl, cycloalkylalkyl,
heterocycloalkyl, heterocycloalkylalkyl, aryl, aralkyl,
30 heteroaryl and heteroaralkyl radicals.

Of highest interest are compounds of Formula IV
wherein:

35 R represents an arylalkanoyl, aryloxycarbonyl,
aryloxyalkanoyl, alkanoyl, aminocarbonyl, mono-

substituted aminoalkanoyl, or disubstituted aminoalkanoyl, or mono-or dialkylaminocarbonyl radical;

5 R' represents hydrogen and radicals as defined for R³ or R and R' together with the nitrogen to which they are attached represent a heterocycloalkyl or heteroaryl radical;

10 R¹, R^{1'} and R^{1''} independently represent hydrogen, methyl, ethyl, benzyl, phenylpropyl and propargyl radicals;

R² represents CH₃SCH₂CH₂-, iso-butyl, n-butyl, benzyl, 4-fluorobenzyl, 2-naphthylmethyl and cyclohexylmethyl radicals;

15

R³ represents alkyl, cyclohexyl, isobutyl, isoamyl and n-butyl radicals; and

20 R⁴ represents methyl, phenyl and substituted phenyl radicals wherein the substituents are selected from halo, alkoxy, amino and nitro substituents.

As utilized herein, the term "alkyl", alone or in combination, means a straight-chain or branched-chain alkyl radical containing from 1 to about 10 carbon atoms, preferably from 1 to about 8 carbon atoms, more preferably 1-5 carbon atoms. Examples of such radicals include methyl, ethyl, n-propyl, isopropyl, n-butyl, isobutyl, sec-butyl, tert-butyl, pentyl, iso-amyl, hexyl, 30 octyl and the like. The term "alkenyl", alone or in combination, means a straight-chain or branched-chain hydrocarbon radical having one or more double bonds and containing from 2 to about 18 carbon atoms, preferably from 2 to about 8 carbon atoms, more preferably from 2 to 35 about 5 carbon atoms. Examples of suitable alkenyl radicals include ethenyl, propenyl, alkyl, 1,4-butadienyl and the like. The term "alkynyl", alone or in

combination, means a straight-chain or branched chain hydrocarbon radical having one or more triple bonds and containing from 2 to about 10 carbon atoms, more preferably from 2 to about 5 carbon atoms. Examples of alkynyl radicals include ethynyl, propynyl, (propargyl), butynyl and the like. The term "alkoxy", alone or in combination, means an alkyl ether radical wherein the term alkyl is as defined above. Examples of suitable alkyl ether radicals include methoxy, ethoxy, n-propoxy, isopropoxy, n-butoxy, iso-butoxy, sec-butoxy, tert-butoxy and the like. The term "cycloalkyl", alone or in combination, means a saturated or partially saturated monocyclic, bicyclic or tricyclic alkyl radical wherein each cyclic moiety contains from about 3 to about 8 carbon atoms, more preferably from about 3 to about 6 carbon atoms. Examples of such cycloalkyl radicals include cyclopropyl, cyclobutyl, cyclopentyl, cyclohexyl and the like. The term "cycloalkylalkyl" means an alkyl radical as defined above which is substituted by a cycloalkyl radical as defined above. Examples of such cycloalkylalkyl radicals include cyclopropylmethyl, cyclobutylmethyl, cyclopentylmethyl, cyclohexylmethyl, 1-cyclopentylethyl, 1-cyclohexylethyl, 2-cyclopentylethyl, 2-cyclohexylethyl, cyclobutylpropyl, cyclopentylpropyl, cyclohexylbutyl and the like. The term "aryl", alone or in combination, means a phenyl or naphthyl radical which optionally carries one or more substituents selected from alkyl, alkoxy, halogen, hydroxy, amino, nitro, cyano, haloalkyl, carboxy, alkoxycarbonyl, cycloalkyl, heterocycloalkyl, amido, mono and dialkyl substituted amino, mono and dialkyl substituted amido and the like, such as phenyl, p-tolyl, 4-methoxyphenyl, 4-(tert-butoxy)phenyl, 3-methyl-4-methoxyphenyl, 4-fluorophenyl, 4-chlorophenyl, 3-nitrophenyl, 3-aminophenyl, 3-acetamidophenyl, 4-acetamidophenyl, 2-methyl-3-acetamidophenyl, 2-methyl-3-aminophenyl, 3-methyl-4-aminophenyl, 2-amino-3-methylphenyl, 2,4-dimethyl-3-

aminophenyl, 4-hydroxyphenyl, 3-methyl-4-hydroxyphenyl, 1-naphthyl, 2-naphthyl, 3-amino-1-naphthyl, 2-methyl-3-amino-1-naphthyl, 6-amino-2-naphthyl, 4,6-dimethoxy-2-naphthyl and the like. The terms "aralkyl" and

5 "aralkoxy", alone or in combination, means an alkyl or alkoxy radical as defined above in which at least one hydrogen atom is replaced by an aryl radical as defined above, such as benzyl, benzyloxy, 2-phenylethyl, dibenzylmethyl, hydroxyphenylmethyl, methylphenylmethyl, and the like. The term "aralkoxycarbonyl", alone or in
10 combination, means a radical of the formula aralkyl-O-C(O)- in which the term "aralkyl" has the significance given above. Examples of an aralkoxycarbonyl radical are benzyloxycarbonyl and 4-methoxyphenylmethoxycarbonyl.

15 The term "aryloxy" means a radical of the formula aryl-O- in which the term aryl has the significance given above.

The term "alkanoyl", alone or in combination, means an acyl radical derived from an alkanecarboxylic acid, examples of which include acetyl, propionyl, butyryl,

20 valeryl, 4-methylvaleryl, and the like. The term "cycloalkylcarbonyl" means an acyl group derived from a monocyclic or bridged cycloalkanecarboxylic acid such as cyclopropylcarbonyl, cyclohexylcarbonyl,

adamantylcarbonyl, and the like, or from a benz-fused

25 monocyclic cycloalkanecarboxylic acid which is optionally substituted by one or more substituents selected from alkyl, alkoxy, halogen, hydroxy, amino, nitro, cyano, haloalkyl, carboxy, alkoxycarbonyl, cycloalkyl,

heterocycloalkyl, alkanoylamino, amido, mono and dialkyl substituted amino, mono and dialkyl substituted amido and
30 the like, such as 1,2,3,4-tetrahydro-2-naphthoyl, 2-acetamido-1,2,3,4-tetrahydro-2-naphthoyl. The term

"aralkanoyl" means an acyl radical derived from an aryl-substituted alkanecarboxylic acid such as phenylacetyl,

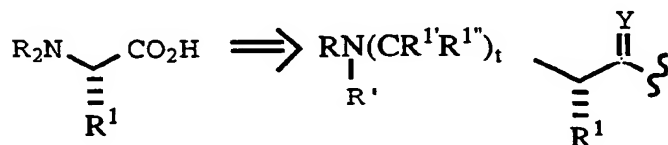
35 3-phenylpropionyl (hydrocinnamoyl), 4-phenylbutyryl, (2-naphthyl)acetyl, 4-chlorohydrocinnamoyl, 4-aminohydrocinnamoyl, 4-methoxyhydrocinnamoyl, and the

like. The term "aroyl" means an acyl radical derived from an arylcarboxylic acid, aryl having the meaning given above. Examples of such arylcarboxylic acid radicals include substituted and unsubstituted benzoic or naphthoic acid such as benzoyl, 4-chlorobenzoyl, 4-carboxybenzoyl, 4-(benzyloxycarbonyl)benzoyl, 1-naphthoyl, 2-naphthoyl, 6-carboxy-2 naphthoyl, 6-(benzyloxycarbonyl)-2-naphthoyl, 3-benzyloxy-2-naphthoyl, 3-hydroxy-2-naphthoyl, 3-(benzyloxyformamido)-2-naphthoyl, and the like. The terms "heterocyclyl" and "heterocycloalkyl," alone or in combination, mean a saturated or partially unsaturated monocyclic, bicyclic or tricyclic heterocycle having preferably 3 to 12 ring members, more preferably 5 to 10 ring members and most preferably 5 to 6 ring members, which contains one or more heteroatom ring members selected from nitrogen, oxygen and sulphur, and which is optionally substituted on one or more carbon atoms by halogen, alkyl, alkoxy, hydroxy, oxo, aryl, aralkyl and the like, and/or on a secondary nitrogen atom (i.e., -NH-) by hydroxy, alkyl, aralkoxycarbonyl, alkanoyl, phenyl or phenylalkyl and/or on a tertiary nitrogen atom (i.e., =N-) by oxido. Heterocycloalkyl and heterocyclyl also includes benz-fused monocyclic cycloalkyl groups having at least one such heteroatom. Heterocycloalkyl and heterocyclyl in addition to sulfur and nitrogen also includes sulfones, sulfoxides and N-oxides of tertiary nitrogen containing heterocycloalkyl groups. The term "heteroaryl", alone or in combination, means an aromatic monocyclic, bicyclic, or tricyclic heterocyclyl (heterocycloalkyl) radical as defined above and is optionally substituted as defined above with respect to the definitions of aryl and heterocyclyl (heterocycloalkyl). Examples of such heterocyclyl (heterocycloalkyl) and heteroaryl groups are pyrrolidinyl, piperidinyl, piperazinyl, morpholinyl, thiamorpholinyl, pyrrolyl, imidazolyl (e.g., imidazol-4-yl, 1-benzyloxycarbonylimidazol-4-yl, etc.), pyrazolyl,

pyridyl, (e.g., 2-(1-piperidinyl)pyridyl and 2-(4-benzyl piperazin-1-yl-1-pyridinyl), pyrazinyl, pyrimidinyl, furyl, tetrahydrofuryl, thienyl, triazolyl, oxazolyl, thiazolyl, indolyl (e.g., 2-indolyl, etc.), quinolinyl, (e.g., 2-quinolinyl, 3-quinolinyl, 1-oxido-2-quinolinyl, etc.), isoquinolinyl (e.g., 1-isoquinolinyl, 3-isoquinolinyl, etc.), tetrahydroquinolinyl (e.g., 1,2,3,4-tetrahydro-2-quinolyl, etc.), 1,2,3,4-tetrahydroisoquinolinyl (e.g., 1,2,3,4-tetrahydro-1-oxo-isoquinolinyl, etc.), quinoxalinyl, β -carbolinyl, 2-benzofurancarbonyl, 1-, 2-, 4- or 5-benzimidazolyl, and the like. The term "cycloalkylalkoxycarbonyl" means an acyl group derived from a cycloalkylalkoxycarboxylic acid of the formula cycloalkylalkyl-O-COOH wherein cycloalkylalkyl has the meaning given above. The term "aryloxyalkanoyl" means an acyl radical of the formula aryl-O-alkanoyl wherein aryl and alkanoyl have the meaning given above. The term "heterocycloalkoxycarbonyl" means an acyl group derived from heterocyclyl-O-COOH wherein heterocyclyl is as defined above. The term "heterocycloalkylalkanoyl" is an acyl radical derived from a heterocycloalkyl-substituted alkylcarboxylic acid wherein heterocycloalkyl has the meaning given above. The term "heterocycloalkylalkoxycarbonyl" means an acyl radical derived from a heterocycloalkyl-substituted alkyl-O-COOH wherein heterocycloalkyl has the meaning given above. The term "heteroaryloxy carbonyl" means an acyl radical derived from a carboxylic acid represented by heteroaryl-O-COOH wherein heteroaryl has the meaning given above. The term "aminocarbonyl" alone or in combination, means an amino-substituted carbonyl (carbamoyl) group wherein the amino group can be a primary, secondary or tertiary amino group containing substituents selected from alkyl, aryl, aralkyl, cycloalkyl, cycloalkylalkyl radicals and the like. The term "aminoalkanoyl" means an acyl group derived from an amino-substituted alkylcarboxylic acid

wherein the amino group can be a primary, secondary or tertiary amino group containing substituents selected from alkyl, aryl, aralkyl, cycloalkyl, cycloalkylalkyl radicals and the like. The term "halogen" means fluorine, chlorine, bromine or iodine. The term "haloalkyl" means an alkyl radical having the meaning as defined above wherein one or more hydrogens are replaced with a halogen. Examples of such haloalkyl radicals include chloromethyl, 1-bromoethyl, fluoromethyl, difluoromethyl, trifluoromethyl, 1,1,1-trifluoroethyl and the like. The term "leaving group" generally refers to groups readily displaceable by a nucleophile, such as an amine, a thiol or an alcohol nucleophile. Such leaving groups are well known in the art. Examples of such leaving groups include, but are not limited to, N-hydroxysuccinimide, N-hydroxybenzotriazole, halides, triflates, tosylates and the like. Preferred leaving groups are indicated herein where appropriate. The term "amino acid side chain" means the side chain group, including the stereochemistry of the carbon to which it is attached, attached to the naturally occurring amino acid which distinguishes the amino acid from glycine. For example, the amino acid side chain of alanine is methyl, of histidine is imidazolylmethyl and phenylalanine is benzyl, and the attachment of such side chains to the compound of this invention retain the naturally occurring stereochemistry of the carbon to which it is attached. The following example illustrates the definition:

30



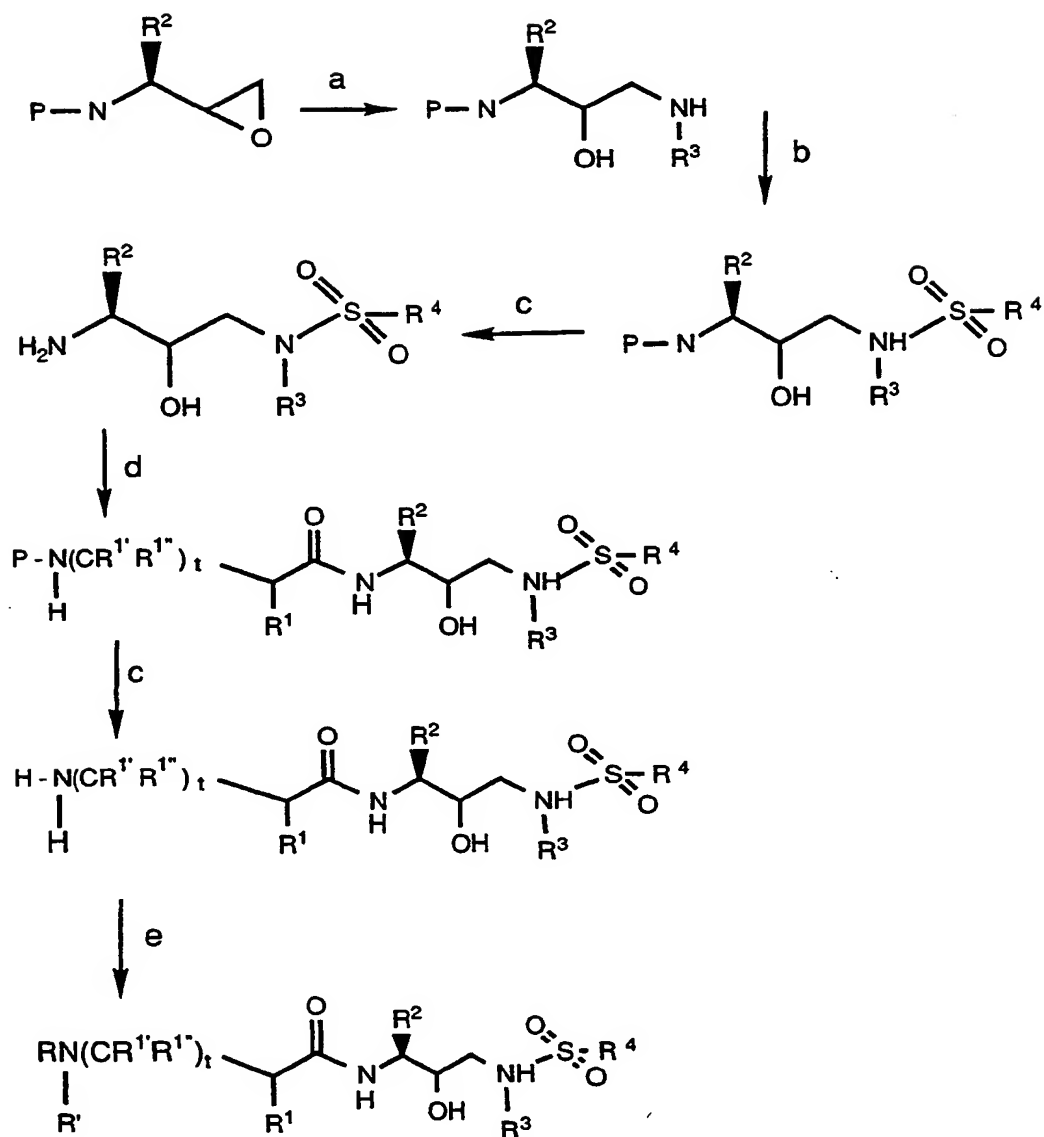
Procedures for preparing the compounds of Formula I are set forth below. It should be noted that
35 the general procedure is shown as it relates to

preparation of compounds having the specified stereochemistry, for example, wherein the absolute stereochemistry about the hydroxyl group is designated as (R). However, such procedures are generally applicable to those compounds of opposite configuration, e.g., where the stereochemistry about the hydroxyl group is (S). In addition, the compounds having the (R) stereochemistry can be utilized to produce those having the (S) stereochemistry. For example, a compound having the (R) stereochemistry can be inverted to the (S) stereochemistry using well-known methods.

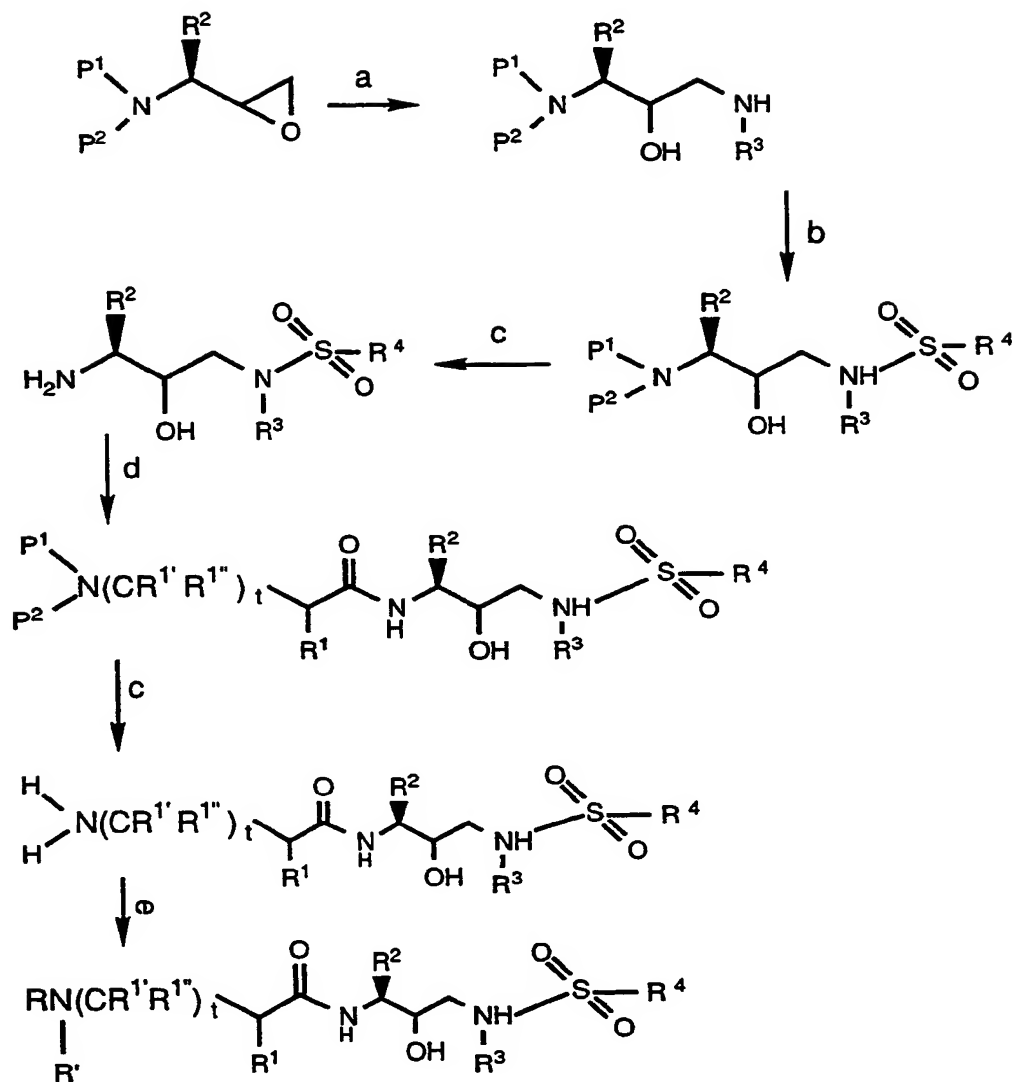
Preparation of Compounds of Formula I

The compounds of the present invention represented by Formula I above can be prepared utilizing the following general procedure. This procedure is schematically shown in the following Schemes I and II:

25

SCHEME I

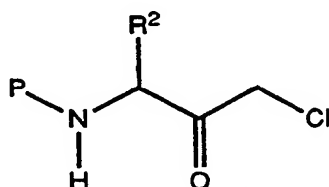
a) amine b) sulfonyl chloride R^4SO_2Cl (or anhydride) + acid scavenger c) deprotection d) coupling e) coupling.

SCHEME II

a) amine b) sulfonyl chloride R^4SO_2Cl (or anhydride) + acid scavenger c) deprotection d) coupling e) coupling.

27

An N-protected chloroketone derivative of an amino acid having the formula:



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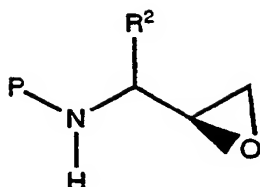
wherein P represents an amino protecting group, and R² is as defined above, is reduced to the corresponding alcohol utilizing an appropriate reducing agent. Suitable amino protecting groups are well known in the art and include carbobenzoxy, t-butoxycarbonyl, and the like. A preferred amino protecting group is carbobenzoxy. A preferred N-protected chloroketone is N-benzyloxycarbonyl-L-phenylalanine chloromethyl ketone. A preferred reducing agent is sodium borohydride. The reduction reaction is conducted at a temperature of from -10°C to about 25°C, preferably at about 0°C, in a suitable solvent system such as, for example, tetrahydrofuran, and the like. The N-protected chloroketones are commercially available, e.g., such as from Bachem, Inc., Torrance, California. Alternatively, the chloroketones can be prepared by the procedure set forth in S. J. Fittkau, J. Prakt. Chem., 315, 1037 (1973), and subsequently N-protected utilizing procedures which are well known in the art.

25

The halo alcohol can be utilized directly, as described below, or, preferably, is then reacted, preferably at room temperature, with a suitable base in a suitable solvent system to produce an N-protected amino epoxide of the formula:

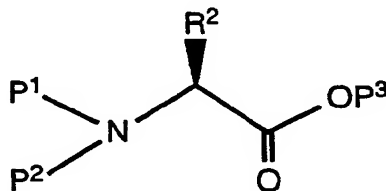
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wherein P and R² are as defined above. Suitable solvent systems for preparing the amino epoxide include ethanol, methanol, isopropanol, tetrahydrofuran, dioxane, and the like including mixtures thereof. Suitable bases for producing the epoxide from the reduced chloroketone include potassium hydroxide, sodium hydroxide, potassium t-butoxide, DBU and the like. A preferred base is potassium hydroxide.

Alternatively, a protected amino epoxide can be prepared, such as in co-owned and co-pending PCT Patent Application Serial No. PCT/US93/04804 which is incorporated herein by reference, starting with an L-amino acid which is reacted with a suitable amino-protecting group in a suitable solvent to produce an amino-protected L-amino acid ester of the formula:



20

wherein P³ represents carboxyl-protecting group, e.g., methyl, ethyl, benzyl, tertiary-butyl and the like; R² is as defined above; and P¹ and P² independently are selected from amine protecting groups, including but not limited to, arylalkyl, substituted arylalkyl, cycloalkenylalkyl and substituted cycloalkenylalkyl, allyl, substituted allyl, acyl, alkoxy carbonyl, aralkoxy carbonyl and silyl. Examples of arylalkyl include, but are not limited to benzyl, ortho-methylbenzyl, trityl and benzhydryl, which can be

optionally substituted with halogen, alkyl of C₁-C₈, alkoxy, hydroxy, nitro, alkylene, amino, alkylamino, acylamino and acyl, or their salts, such as phosphonium and ammonium salts. Examples of aryl groups include phenyl, naphthalenyl, indanyl, anthracenyl, durenyl, 9-(9-phenylfluorenyl) and phenanthrenyl, cycloalkenylalkyl or substituted cycloalkylenylalkyl radicals containing cycloalkyls of C₆-C₁₀. Suitable acyl groups include carbobenzoyl, t-butoxycarbonyl, iso-butoxycarbonyl, benzoyl, substituted benzoyl, butyryl, acetyl, tri-fluoroacetyl, tri-chloroacetyl, phthaloyl and the like.

Additionally, the P¹ and/or P² protecting groups can form a heterocyclic ring with the nitrogen to which they are attached, for example, 1,2-bis(methylene)benzene, phthalimidyl, succinimidyl, maleimidyl and the like and where these heterocyclic groups can further include adjoining aryl and cycloalkyl rings. In addition, the heterocyclic groups can be mono-, di- or tri-substituted, e.g., nitrophthalimidyl. The term silyl refers to a silicon atom optionally substituted by one or more alkyl, aryl and aralkyl groups.

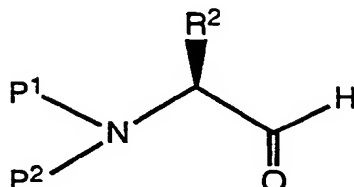
Suitable silyl protecting groups include, but are not limited to, trimethylsilyl, triethylsilyl, tri-isopropylsilyl, tert-butyl dimethylsilyl, dimethylphenylsilyl, 1,2-bis(dimethylsilyl)benzene, 1,2-bis(dimethylsilyl)ethane and diphenylmethylsilyl. Silylation of the amine functions to provide mono- or bis-disilylamine can provide derivatives of the aminoalcohol, amino acid, amino acid esters and amino acid amide. In the case of amino acids, amino acid esters and amino acid amides, reduction of the carbonyl function provides the required mono- or bis-silyl aminoalcohol. Silylation of the aminoalcohol can lead to the N,N,O-tri-silyl derivative. Removal of the silyl function from the silyl ether function is readily accomplished by treatment with, for example, a

metal hydroxide or ammonium fluoride reagent, either as a discrete reaction step or in situ during the preparation of the amino aldehyde reagent. Suitable silylating agents are, for example, trimethylsilyl chloride, tert-buty-
5 dimethylsilyl chloride, phenyldimethylsilyl chloride, diphenylmethylsilyl chloride or their combination products with imidazole or DMF. Methods for silylation of amines and removal of silyl protecting groups are well known to those skilled in the art. Methods of preparation of these amine
10 derivatives from corresponding amino acids, amino acid amides or amino acid esters are also well known to those skilled in the art of organic chemistry including amino acid/amino acid ester or aminoalcohol chemistry.

15 Preferably P^1 and P^2 are independently selected from aralkyl and substituted aralkyl. More preferably, each of P^1 and P^2 is benzyl. As illustrated in the Examples below, P, P^1 and P^2 may serve as a nitrogen protecting group which is later removed in the
20 preparation of compounds of this invention or may form a part of the final inhibitor structure. For example, benzoyl, benzyloxycarbonyl, t-butoxycarbonyl, pyridylmethoxycarbonyl, tetrahydrofuryloxycarbonyl, pyridylcarbonyl and the like can be used to both protect a
25 nitrogen from undergoing an undesired reaction and also be part of the structure of an active enzyme inhibitor.

The amino-protected L-amino acid ester is then reduced, to the corresponding alcohol. For example, the
30 amino-protected L-amino acid ester can be reduced with diisobutylaluminum hydride at -78°C in a suitable solvent such as toluene. Preferred reducing agents include lithium aluminium hydride, lithium borohydride, sodium borohydride, borane, lithium tri-ter-
35 butoxyaluminum hydride, borane/THF complex. Most preferably, the reducing agent is diisobutylaluminum hydride (DiBAL-H) in toluene. The resulting alcohol is

then converted, for example, by way of a Swern oxidation, to the corresponding aldehyde of the formula:



wherein P¹, P² and R² are as defined above. Thus, a dichloromethane solution of the alcohol is added to a cooled (-75 to -68° C) solution of oxalyl chloride in dichloromethane and DMSO in dichloromethane and stirred for 35 minutes.

Acceptable oxidizing reagents include, for example, sulfur trioxide-pyridine complex and DMSO, oxalyl chloride and DMSO, acetyl chloride or anhydride and DMSO, trifluoroacetyl chloride or anhydride and DMSO, methanesulfonyl chloride and DMSO or tetrahydro thiaphene-S-oxide, toluenesulfonyl bromide and DMSO, trifluoromethanesulfonyl anhydride (triflic anhydride) and DMSO, phosphorus pentachloride and DMSO, dimethylphosphoryl chloride and DMSO and isobutyl chloroformate and DMSO. The oxidation conditions reported by Reetz et al [Angew Chem., 99, p. 1186, (1987)], Angew Chem. Int. Ed. Engl., 26, p. 1141, 1987) employed oxalyl chloride and DMSO at -78°C.

The preferred oxidation method described in this invention is sulfur trioxide pyridine complex, triethylamine and DMSO at room temperature. This system provides excellent yields of the desired chiral protected amino aldehyde usable without the need for purification i.e., the need to purify kilograms of intermediates by chromatography is eliminated and large scale operations are made less hazardous. Reaction at room temperature also eliminated the need

for the use of low temperature reactor which makes the process more suitable for commercial production.

The reaction may be carried out under and
5 inert atmosphere such as nitrogen or argon, or normal
or dry air, under atmospheric pressure or in a sealed
reaction vessel under positive pressure. Preferred is
a nitrogen atmosphere. Alternative amine bases
include, for example, tri-butyl amine, tri-isopropyl
10 amine, N-methylpiperidine, N-methyl morpholine,
azabicyclononane, diisopropylethylamine, 2,2,6,6-
tetramethylpiperidine, N,N-dimethylaminopyridine, or
mixtures of these bases. Triethylamine is a preferred
base. Alternatives to pure DMSO as solvent include
15 mixtures of DMSO with non-protic or halogenated
solvents such as tetrahydrofuran, ethyl acetate,
toluene, xylene, dichloromethane, ethylene dichloride
and the like. Dipolar aprotic co-solvents include
acetonitrile, dimethylformamide, dimethylacetamide,
20 acetamide, tetramethyl urea and its cyclic analog,
N-methylpyrrolidone, sulfolane and the like. Rather
than N,N-dibenzylphenylalaninol as the aldehyde
precursor, the phenylalaninol derivatives discussed
above can be used to provide the corresponding
25 N-monosubstituted [either P^1 or $P^2 = H$] or N,N-
disubstituted aldehyde.

In addition, hydride reduction of an amide
or ester derivative of the corresponding alkyl, benzyl
30 or cycloalkenyl nitrogen protected phenylalanine,
substituted phenylalanine or cycloalkyl analog of
phenylalanine derivative can be carried out to provide
the aldehydes. Hydride transfer is an additional
method of aldehyde synthesis under conditions where
35 aldehyde condensations are avoided, cf, Oppenauer
Oxidation.

The aldehydes of this process can also be prepared by methods of reducing protected phenylalanine and phenylalanine analogs or their amide or ester derivatives by, e.g., sodium amalgam with HCl in ethanol or lithium or sodium or potassium or calcium in ammonia. The reaction temperature may be from about -20°C to about 45°C, and preferably from about 5°C to about 25°C. Two additional methods of obtaining the nitrogen protected aldehyde include oxidation of the corresponding alcohol with bleach in the presence of a catalytic amount of 2,2,6,6-tetramethyl-1-pyridyloxy free radical. In a second method, oxidation of the alcohol to the aldehyde is accomplished by a catalytic amount of tetrapropylammonium perruthenate in the presence of N-methylmorpholine-N-oxide.

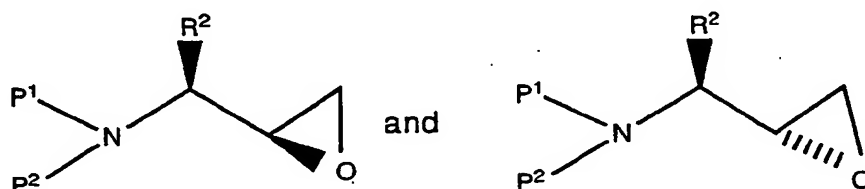
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Alternatively, an acid chloride derivative of a protected phenylalanine or phenylalanine derivative as disclosed above can be reduced with hydrogen and a catalyst such as Pd on barium carbonate or barium sulphate, with or without an additional catalyst moderating agent such as sulfur or a thiol (Rosenmund Reduction).

20

The aldehyde resulting from the Swern oxidation is then reacted with a halomethyl lithium reagent, which reagent is generated in situ by reacting an alkyl lithium or aryl lithium compound with a dihalomethane represented by the formula $X^1CH_2X^2$ wherein X^1 and X^2 independently represent I, Br or Cl. For example, a solution of the aldehyde and chloriodomethane in THF is cooled to -78° C and a solution of n-butyllithium in hexane is added. The resulting product is a mixture of diastereomers of the corresponding amino-protected epoxides of the formulas:

30



The diastereomers can be separated e.g., by chromatography, or, alternatively, once reacted in subsequent steps the diastereomeric products can be separated. For compounds having the (S) stereochemistry, a D-amino acid can be utilized in place of the L-amino acid.

The addition of chloromethylithium or bromomethylithium to a chiral amino aldehyde is highly diastereoselective. Preferably, the chloromethylithium or bromomethylithium is generated in-situ from the reaction of the dihalomethane and n-butyllithium. Acceptable methyleneating halomethanes include chloriodomethane, bromochloromethane, dibromomethane, diiodomethane, bromofluoromethane and the like. The sulfonate ester of the addition product of, for example, hydrogen bromide to formaldehyde is also a methyleneating agent. Tetrahydrofuran is the preferred solvent, however alternative solvents such as toluene, dimethoxyethane, ethylene dichloride, methylene chloride can be used as pure solvents or as a mixture. Dipolar aprotic solvents such as acetonitrile, DMF, N-methylpyrrolidone are useful as solvents or as part of a solvent mixture. The reaction can be carried out under an inert atmosphere such as nitrogen or argon. For n-butyl lithium can be substituted other organometallic reagents reagents such as methylithium, tert-butyl lithium, sec-butyl lithium, phenyllithium, phenyl sodium and the like. The reaction can be carried out at temperatures of between about -80°C to 0°C but preferably between about -80°C to -20°C. The most preferred reaction temperatures are between -40°C to -15°C. Reagents can be added singly but multiple additions are preferred in certain conditions. The preferred pressure of the reaction is atmospheric however a positive pressure is valuable under certain conditions such as a high humidity environment.

Alternative methods of conversion to the epoxides of this invention include substitution of other charged methylenation precursor species followed by their treatment with base to form the analogous anion. Examples of these species include trimethylsulfoxonium tosylate or triflate, tetramethylammonium halide, methyldiphenylsulfoxonium halide wherein halide is chloride, bromide or iodide.

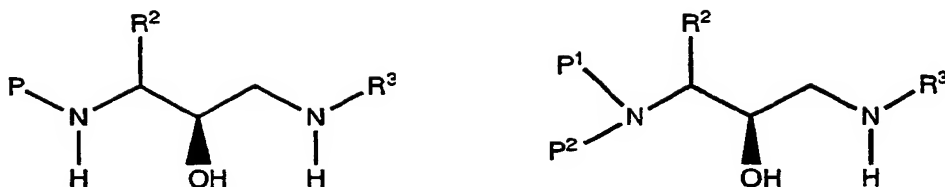
The conversion of the aldehydes of this invention into their epoxide derivative can also be carried out in multiple steps. For example, the addition of the anion of thioanisole prepared from, for example, a butyl or aryl lithium reagent, to the protected aminoaldehyde, oxidation of the resulting protected aminosulfide alcohol with well known oxidizing agents such as hydrogen peroxide, tert-butyl hypochlorite, bleach or sodium periodate to give a sulfoxide. Alkylation of the sulfoxide with, for example, methyl iodide or bromide, methyl tosylate, methyl mesylate, methyl triflate, ethyl bromide, isopropyl bromide, benzyl chloride or the like, in the presence of an organic or inorganic base. Alternatively, the protected aminosulfide alcohol can be alkylated with, for example, the alkylating agents above, to provide a sulfonium salts that are subsequently converted into the subject epoxides with tert-amine or mineral bases.

The desired epoxides formed, using most preferred conditions, diastereoselectively in ratio amounts of at least about an 85:15 ratio (S:R). The product can be purified by chromatography to give the diastereomerically and enantiomerically pure product but it is more conveniently used directly without purification to prepare retroviral protease inhibitors. The foregoing process is applicable to mixtures of optical isomers as well as resolved compounds. If a particular optical isomer is desired, it can be selected by the choice of starting material, e.g., L-phenylalanine, D-phenylalanine, L-

phenylalaninol, D-phenylalaninol, D-hexahydrophenylalaninol and the like, or resolution can occur at intermediate or final steps. Chiral auxiliaries such as one or two
5 equivilants of camphor sulfonic acid, citric acid, camphoric acid, 2-methoxyphenylacetic acid and the like can be used to form salts, esters or amides of the compounds of this invention. These compounds or derivatives can be crystallized or separated chromatographically using either a
10 chiral or achiral column as is well known to those skilled in the art.

The amino epoxide is then reacted, in a suitable solvent system, with an equal amount, or preferably an excess of, a desired amine of the formula
15 R^3NH_2 , wherein R^3 is hydrogen or is as defined above. The reaction can be conducted over a wide range of temperatures, e.g., from about 10°C to about 100°C, but is preferably, but not necessarily, conducted at a temperature at which the solvent begins to reflux.
20 Suitable solvent systems include protic, non-protic and dipolar aprotic organic solvents such as, for example, those wherein the solvent is an alcohol, such as methanol, ethanol, isopropanol, and the like, ethers such as tetrahydrofuran, dioxane and the like, and toluene,
25 N,N-dimethylformamide, dimethyl sulfoxide, and mixtures thereof. A preferred solvent is isopropanol. Exemplary amines corresponding to the formula R^3NH_2 include benzyl amine, isobutylamine, n-butyl amine, isopentyl amine, isoamylamine, cyclohexanemethyl amine, naphthylene methyl
30 amine and the like. The resulting product is a 3-(N-protected amino)-3-(R^2)-1-(NHR^3)-propan-2-ol derivative (hereinafter referred to as an amino alcohol) can be represented by the formulas:

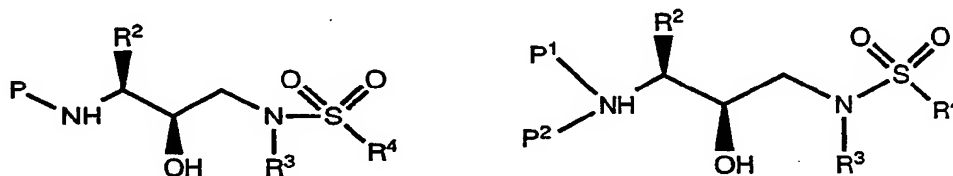
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wherein P, P¹, P², R² and R³ are as described above.

Alternatively, a haloalcohol can be utilized in place of
5 the amino epoxide.

The amino alcohol defined above is then reacted
in a suitable solvent with a sulfonyl chloride (R⁴SO₂Cl)
or sulfonyl anhydride in the presence of an acid
10 scavenger. Suitable solvents in which the reaction can
be conducted include methylene chloride, tetrahydrofuran.
Suitable acid scavengers include triethylamine, pyridine.
Preferred sulfonyl chlorides are methanesulfonyl chloride
and benzenesulfonyl chloride. The resulting sulfonamide
15 derivative can be represented, depending on the epoxide
utilized by the formulas



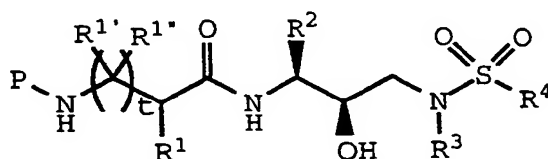
20 wherein P, P¹, P², R², R³ and R⁴ are as defined above.
These intermediates are useful for preparing inhibitor
compounds of the present invention and are also active
inhibitors of retroviral proteases.

25 The sulfonyl halides of the formula R⁴SO₂X can
be prepared by the reaction of a suitable Grignard or
alkyl lithium reagent with sulfuryl chloride, or sulfur
dioxide followed by oxidation with a halogen, preferably
chlorine. Also, thiols may be oxidized to sulfonyl
30 chlorides using chlorine in the presence of water under
carefully controlled conditions. Additionally, sulfonic

acids may be converted to sulfonyl halides using reagents such as PCl_5 , and also to anhydrides using suitable dehydrating reagents. The sulfonic acids may in turn be prepared using procedures well known in the art. Such
 5 sulfonic acids are also commercially available. In place of the sulfonyl halides, sulfinyl halides (R^4SOX) or sulfenyl halides (R^4SX) can be utilized to prepare compounds wherein the $-\text{SO}_2-$ moiety is replaced by an $-\text{SO}-$ or $-\text{S}-$ moiety, respectively.

10

Following preparation of the sulfonamide derivative, the amino protecting group P or P^1 and P^2 amino protecting groups are removed under conditions which will not affect the remaining portion of the
 15 molecule. These methods are well known in the art and include acid hydrolysis, hydrogenolysis and the like. A preferred method involves removal of the protecting group, e.g., removal of a carbobenzoxy group, by hydrogenolysis utilizing palladium on carbon in a
 20 suitable solvent system such as an alcohol, acetic acid, and the like or mixtures thereof. Where the protecting group is a t-butoxycarbonyl group, it can be removed utilizing an inorganic or organic acid, e.g., HCl or trifluoroacetic acid, in a suitable solvent system, e.g.,
 25 dioxane or methylene chloride. The resulting product is the amine salt derivative. Following neutralization of the salt, the amine is then reacted with an amino acid or corresponding derivative thereof represented by the formula $(\text{PN}[\text{CR}^1 \text{ R}^1']_t \text{ CH}(\text{R}^1)\text{COOH})$ wherein t, R^1 , R^1' and
 30 R^1'' are as defined above, to produce the antiviral compounds of the present invention having the formula:



39.

wherein t, P, R¹, R^{1'}, R^{1''}, R², R³ and R⁴ are as defined above. Preferred protecting groups in this instance are a benzyloxycarbonyl group or a t-butoxycarbonyl group.

Where t is O and R¹ is alkyl, alkenyl, alkynyl, cycloalkyl, -CH₂SO₂NH₂, -CH₂CO₂CH₃, -CO₂CH₃, -CONH₂, -CH₂C(O)NHCH₃, -C(CH₃)₂(SH), -C(CH₃)₂(SCH₃), -C(CH₃)₂[S(O)CH₃], -C(CH₃)₂[S(O₂)CH₃], or an amino acid side chain, such materials are well known and many are commercially available from Sigma-Aldrich.

10

Where the amine is reacted with a derivative of an amino acid, e.g., when t=1, so that the amino acid is a β-amino acid, such β-amino acids can be prepared according to the procedure set forth in a co-owned, copending patent application, U.S. Serial No. 07/853,561 or the following procedures.

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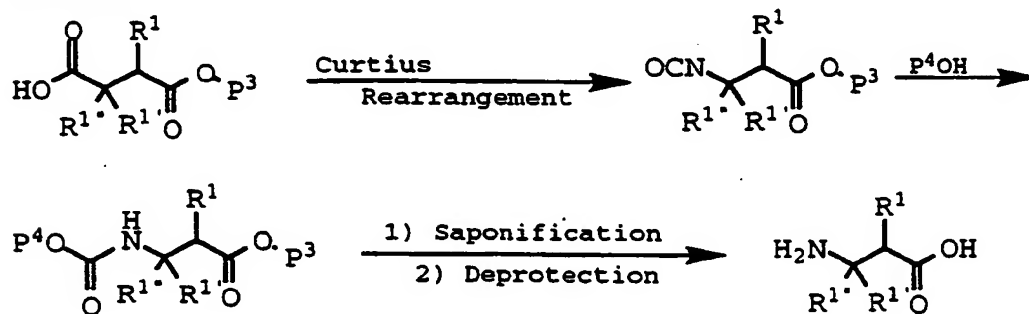
Various methods have been proposed for the preparation of chiral β-amino acids. See, for example, Chemistry and Biochemistry of Amino Acids, Vol. 4, Chapter 5, pp. 250-57, B. Weinstein, Ed., Dekker, N.Y. (1975). Furukawa et al, Chem. Pharm. Bull., 25, 1319 (1977), disclose asymmetric synthesis of β-amino acids by addition of chiral amines to carbon-carbon double bonds having nitrile or ester groups in the α-position. However, optical purities of the β-amino acids thus produced range from 2 to 19%. Furukawa et al also report that optically active β-amino acids have been produced with optical purities ranging from 2 to 28% by reacting chiral Schiff bases with Reformsky reagent. Terentev et al, Dohl. Akad. Nauk SSR, 163,674 (1965) disclose synthesis of β-aminobutyric acids involving addition of chiral amines to crotonic acid with optical purities ranging from 7-9%.

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Brown et al, Tetrahedron Lett., Vol. 28, No. 19, pp 2179-2182 (1987), disclose a method of preparing

optically active disubstituted β -amino acids which involves asymmetric catalytic hydrogenation of N-substituted α -(aminoalkyl) acrylates. In order to verify the stereochemistry of the product, Curtius rearrangement was effected on the monomethyl ester of optically enriched RR-anti-2,3-dimethyl-succinic acid and trapping of the incipient isocyanate derivative with tertiary alcohol, namely, t-butyl alcohol, to give the corresponding R-enriched β -amino acid. Ninomita et al, Tetrahedron Lett., Vol. 30, 2152-2157 (1975) studied the Curtius rearrangement utilizing benzoic acid, diphenylphosphoryl azide and triethylamine followed by treatment with various alcohols and found that t-butyl alcohol gives yields superior to benzyl alcohol, ethanol and phenol.

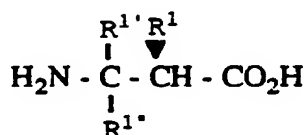
Utilization of a primary or secondary alcohol to trap an isocyanate derivative of a chiral mono-substituted succinate, and, in particular, in a Curtius rearrangement of a chiral mono-substituted succinate, to produce chiral β -amino acids significantly increases the overall yield. The resulting carbamate-protected β -amino esters are then saponified to produce the corresponding carbamate-protected β -amino acids which are then deprotected to produce β -amino acids possessing the same absolute configuration as naturally-occurring (L)-amino acids. The overall reaction sequence can be shown as follow:



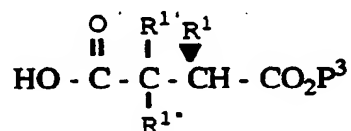
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wherein R^1 , $R^{1'}$, $R^{1''}$, and P^3 are as defined above and P^4OH are preferably represents radicals derived from primary and secondary alcohols.

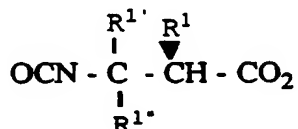
- 5 This process can also be used in the asymmetric synthesis of β -amino acids represented by the formula:



- 10 wherein R^1 , $R^{1'}$ and $R^{1''}$ are as defined above. Such compounds are formed by Curtius rearrangement of 2(R)-substituted succinates represented by the formula



- 15 wherein R^1 , $R^{1'}$, $R^{1''}$ and P^3 are as defined above, to afford the isocyanate derivative:



- 20 Using 2(S)-substituted succinates, 2(S)-substituted β -amino acids can also be prepared stereospecifically.

- Curtius rearrangement involves pyrolysis of
- 25 acyl azides ($R-\overset{\overset{O}{||}}{C}-N=N=N$) to yield isocyanates ($R-N=C=O$) which can be subsequently hydrolyzed to give amines. See March, Advanced Organic Chemistry, p. 1005, 2nd ed (1977). As a general rule, Curtius rearrangement is a concerted reaction and therefore proceeds with retention
- 30 of configuration of the starting materials.

Determination of specific reaction conditions for effecting Curtius rearrangements of various succinates is within the skill of one in the art familiar with such reactions. In the method of the present invention,

5 Curtius rearrangement to afford the desired isocyanate is preferably effected by treating a 2-substituted succinate with one equivalent of diphenoxyphosphoryl azide $(\text{PhO})_2\text{PON}_3$ and triethylamine to form the acyl azide followed by heating in an inert solvent, such as in warm

10 toluene, preferably at about 80°C for about three hours, to afford the isocyanate derivative.

Suitable primary and secondary alcohols include those represented by the formula P^4OH where P^4

15 represents substituted and unsubstituted alkyl, cycloalkyl, aralkyl and aryl radicals, as well as suitable equivalents such as, for example, silyl radicals. Preferably, the primary and secondary alcohols are those wherein P^4 represents substituted and

20 unsubstituted, straight chain as well as branched chain, alkyl radicals having from 1 to about 12 carbon atoms, substituted and unsubstituted cycloalkyl radicals having from 4 to about 7 carbon atoms, and substituted and unsubstituted aryl, alkaryl and aralkyl radicals.

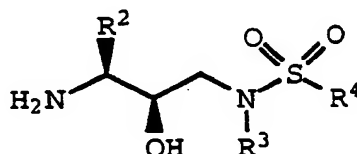
25 Examples of such suitable alcohols include benzyl alcohol, isopropyl alcohol, 4-methoxybenzyl alcohol, 2-trimethylsilylethanol, fluorenyl methanol and benzhydrol. Preferred alcohols are benzyl alcohol and 4-methoxybenzyl alcohol. Other primary and secondary alcohols suitable

30 for use in the practice of the present invention will be readily apparent to those skilled in the art.

The ester derivative is then saponified by any one of numerous well-known procedures, such as by

35 treatment with aqueous lithium hydroxide/THF (tetrahydrofuran), preferably for three hours at 0°C . The resultant product is the corresponding carbamate-

protected β -amino acids. These are subsequently deprotected by any one of several well-known procedures, such as by acid catalyzed hydrolysis or by hydrogenolysis, to produce the corresponding deprotected β -amino acids. Alternatively, the carbamate-protected β -amino acid can be coupled to the amine



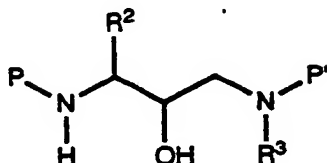
followed by deprotection and incorporation of R and R'.
10

The N-protecting group can be subsequently removed, if desired, utilizing the procedures described above, and then reacted with a carboxylate represented by

the formula $\text{R}-\overset{\text{O}}{\parallel}{\text{C}}-\text{L}$, wherein R is as defined above and
15 L is an appropriate leaving group such as a halide. Preferably, where R¹ is a side chain of a naturally occurring α -amino acid, R is a 2-quinoline carbonyl group derived from N-hydroxysuccinimide-2-quinoline carboxylate, i.e., L is hydroxy succinimide. A solution
20 of the free amine (or amine acetate salt) and about 1.0 equivalent of the carboxylate are mixed in an appropriate solvent system and optionally treated with up to five equivalents of a base such as, for example, N-methylmorpholine, at about room temperature. Appropriate
25 solvent systems include tetrahydrofuran, methylene chloride or N,N-dimethyl formamide, and the like, including mixtures thereof.

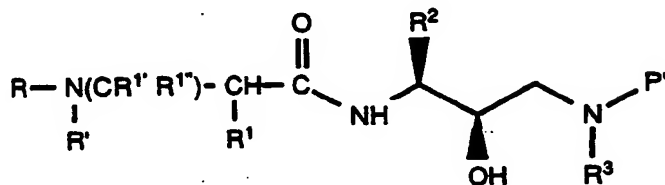
Alternatively, the protected amino alcohol from
30 the epoxide opening can be further protected at the newly introduced amino group with a protecting group P' which is not removed when the first protecting P is removed. One skilled in the art can choose appropriate combinations of P

and P'. One suitable choice is when P is Cbz and P' is Boc. The resulting compound represented by the formula:



5

can be carried through the remainder of the synthesis to provide a compound of the formula:



10

and the new protecting group P' is selectively removed, and following deprotection, the resulting amine reacted to form the sulfonamide derivative as described above. This selective deprotection and conversion to the sulfonamide can be accomplished at either the end of the synthesis or at any appropriate intermediate step if desired.

15

The thiocarbonyl compounds of this invention are really prepared by methods well known to those skilled in the art, for example, by treatment of a carbonyl compound with Lawesson's reagent (2,4-bis(4-methoxyphenyl)-1,3-dithia-2,4-diphosphetane-2,4-disulfide) which is an article of commerce. Phosphorus pentasulfide may also be used or one can treat an amine of this invention with a pre-formed thiocarbonyl reagent such as thiocarbonylchlorid in the presence of base.

20

25

In place of the sulfonyl halides, sulfinyl halides (RSOCl) and sulfenyl halides (RSCl) can be utilized to prepare compounds wherein the -SO₂- moiety is replaced by -SO- or -S-, respectively.

30

It is contemplated that for preparing compounds of the Formulas having R^6 , the compounds can be prepared following the procedure set forth above and, prior to
5 coupling the sulfonamide derivative or analog thereof, e.g. coupling to the amino acid $PNH(CH_2)_tCH(R^1)COOH$, carried through a procedure referred to in the art as reductive amination. Thus, a sodium cyanoborohydride and an appropriate aldehyde or ketone can be reacted with the
10 sulfonamide derivative compound or appropriate analog at room temperature in order to reductively aminate any of the compounds of Formulas I-IV. It is also contemplated that where R^3 of the amino alcohol intermediate is hydrogen, the inhibitor compounds of the present
15 invention wherein R^3 is alkyl, or other substituents wherein the α -C contains at least one hydrogen, can be prepared through reductive amination of the final product of the reaction between the amino alcohol and the amine or at any other stage of the synthesis for preparing the
20 inhibitor compounds.

Contemplated equivalents of the general formulas set forth above for the antiviral compounds and derivatives as well as the intermediates are compounds
25 otherwise corresponding thereto and having the same general properties, such as tautomers thereof as well as compounds, wherein one or more of the various R groups are simple variations of the substituents as defined therein, e.g., wherein R is a higher alkyl group than
30 that indicated. In addition, where a substituent is designated as, or can be, a hydrogen, the exact chemical nature of a substituent which is other than hydrogen at that position, e.g., a hydrocarbyl radical or a halogen, hydroxy, amino and the like functional group, is not
35 critical so long as it does not adversely affect the overall activity and/or synthesis procedure.

The chemical reactions described above are generally disclosed in terms of their broadest application to the preparation of the compounds of this invention. Occasionally, the reactions may not be applicable as described to each compound included within the disclosed scope. The compounds for which this occurs will be readily recognized by those skilled in the art. In all such cases, either the reactions can be successfully performed by conventional modifications known to those skilled in the art, e.g., by appropriate protection of interfering groups, by changing to alternative conventional reagents, by routine modification of reaction conditions, and the like, or other reactions disclosed herein or otherwise conventional, will be applicable to the preparation of the corresponding compounds of this invention. In all preparative methods, all starting materials are known or readily preparable from known starting materials.

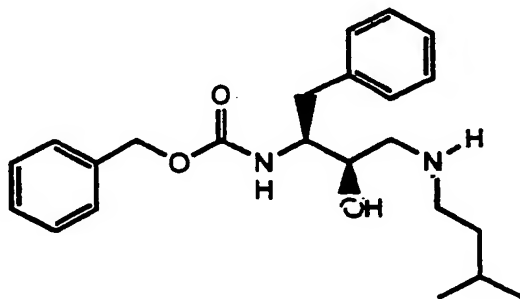
Without further elaboration, it is believed that one skilled in the art can, using the preceding description, utilize the present invention to its fullest extent. The following preferred specific embodiments are, therefore, to be construed as merely illustrative, and not limitative of the remainder of the disclosure in any way whatsoever.

All reagents were used as received without purification. All proton and carbon NMR spectra were obtained on either a Varian VXR-300 or VXR-400 nuclear magnetic resonance spectrometer.

The following Examples 1 through 9 illustrate preparation of intermediates. These intermediates are useful in preparing the inhibitor compounds of the

present invention as illustrated in Examples 10-16. In addition, the intermediates of Examples 2-6 are also retroviral protease inhibitors and inhibit, in particular, HIV protease.

5

Example 1A

10 Preparation of N[3(S)-benzyloxycarbonylamino-2(R)-
hydroxy-4-phenylbutyl]-N-isoamylamine

Part A:

To a solution of 75.0g (0.226 mol) of
15 N-benzyloxycarbonyl-L-phenylalanine chloromethyl ketone
in a mixture of 807 mL of methanol and 807 mL of
tetrahydrofuran at -2°C, was added 13.17g (0.348 mol,
1.54 equiv.) of solid sodium borohydride over one hundred
minutes. The solvents were removed under reduced
20 pressure at 40°C and the residue dissolved in ethyl
acetate (approx. 1L). The solution was washed
sequentially with 1M potassium hydrogen sulfate,
saturated sodium bicarbonate and then saturated sodium
chloride solutions. After drying over anhydrous
25 magnesium sulfate and filtering, the solution was removed
under reduced pressure. To the resulting oil was added
hexane (approx. 1L) and the mixture warmed to 60°C with
swirling. After cooling to room temperature, the solids
were collected and washed with 2L of hexane. The
30 resulting solid was recrystallized from hot ethyl acetate
and hexane to afford 32.3g (43% yield) of

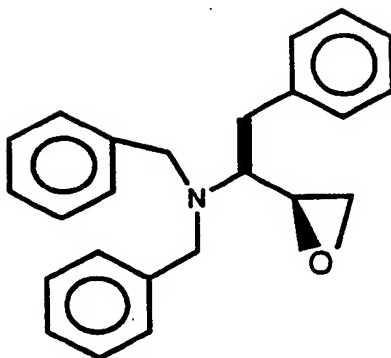
N-benzyloxycarbonyl-3(S)-amino-1-chloro-4-phenyl-2(S)-butanol, mp 150-151°C and $M+Li^+ = 340$.

Part B:

5 To a solution of 6.52g (0.116 mol, 1.2 equiv.) of potassium hydroxide in 968 mL of absolute ethanol at room temperature, was added 32.3g (0.097 mol) of N-CBZ-3(S)-amino-1-chloro-4-phenyl-2(S)-butanol. After stirring for fifteen minutes, the solvent was removed
10 under reduced pressure and the solids dissolved in methylene chloride. After washing with water, drying over magnesium sulfate, filtering and stripping, one obtains 27.9g of a white solid. Recrystallization from hot ethyl acetate and hexane afforded 22.3g (77% yield)
15 of N-benzyloxycarbonyl-3(S)-amino-1,2(S)-epoxy-4-phenylbutane, mp 102-103°C and $MH^+ 298$.

Part C:

20 A solution of N-benzyloxycarbonyl 3(S)-amino-1,2-(S)-epoxy-4-phenylbutane (1.00g, 3.36 mmol) and isoamylamine (4.90g, 67.2 mmol, 20 equiv.) in 10 mL of isopropyl alcohol was heated to reflux for 1.5 hours. The solution was cooled to room temperature, concentrated in vacuo and then poured into 100 mL of stirring hexane
25 whereupon the product crystallized from solution. The product was isolated by filtration and air dried to give 1.18g, 95% of N-[[3(S)-phenylmethylcarbamoyl]amino-2(R)-hydroxy-4-phenylbutyl]N-[(3-methylbutyl)]amine mp 108.0-109.5°C, $MH^+ m/z = 371$.

Example 1B

5 Preparation of N,N-dibenzyl-3(S)-amino-1,2-(S)-epoxy-4-
phenylbutane

Step A:

A solution of L-phenylalanine (50.0 g, 0.302 mol),
10 sodium hydroxide (24.2 g, 0.605 mol) and potassium
carbonate (83.6 g, 0.605 mol) in water (500 ml) was
heated to 97°C. Benzyl bromide (108.5 ml, 0.912 mol) was
then slowly added (addition time ~25 min). The mixture
was then stirred at 97°C for 30 minutes. The solution
15 was cooled to room temperature and extracted with toluene
(2 x 250 ml). The combined organic layers were then
washed with water, brine, dried over magnesium sulfate,
filtered and concentrated to give an oil product. The
crude product was then used in the next step without
20 purification.

Step B:

The crude benzylated product of the above step was
dissolved in toluene (750 ml) and cooled to -55°C. A 1.5
25 M solution of DIBAL-H in toluene (443.9 ml, 0.666 mol)
was then added at a rate to maintain the temperature
between -55° to -50°C (addition time - 1 hour). The
mixture was stirred for 20 minutes at -55°C. The
reaction was quenched at -55°C by the slow addition of

methanol (37 ml). The cold solution was then poured into cold (5°C) 1.5 N HCl solution (1.8 L). The precipitated solid (approx. 138 g) was filtered off and washed with toluene. The solid material was suspended in a mixture
5 of toluene (400 ml) and water (100 ml). The mixture was cooled to 5°C, treated with 2.5 N NaOH (186 ml) and then stirred at room temperature until the solid was dissolved. The toluene layer was separated from the aqueous phase and washed with water and brine, dried over
10 magnesium sulfate, filtered and concentrated to a volume of 75 ml (89 g). Ethyl acetate (25 ml) and hexane (25 ml) were then added to the residue upon which the alcohol product began to crystallize. After 30 min., an additional 50 ml hexane was added to promote further
15 crystallization. The solid was filtered off and washed with 50 ml hexane to give approximately 35 g of material. A second crop of material could be isolated by refiltering the mother liquor. The solids were combined and recrystallized from ethyl acetate (20 ml) and hexane
20 (30 ml) to give, in 2 crops, approximately 40 g (40% from L-phenylalanine) of analytically pure alcohol product. The mother liquors were combined and concentrated (34 g). The residue was treated with ethyl acetate and hexane which provided an additional 7 g (~7% yield) of slightly
25 impure solid product. Further optimization in the recovery from the mother liquor is probable.

Alternatively, the alcohol was prepared from L-phenylalaninol. L-phenylalaninol (176.6 g, 1.168 mol)
30 was added to a stirred solution of potassium carbonate (484.6 g, 3.506 mol) in 710 mL of water. The mixture was heated to 65°C under a nitrogen atmosphere. A solution of benzyl bromide (400 g, 2.339 mol) in 3A ethanol (305 mL) was added at a rate that maintained
35 the temperature between 60-68°C. The biphasic solution was stirred at 65°C for 55 min and then allowed to cool to 10°C with vigorous stirring. The

51

oily product solidified into small granules. The product was diluted with 2.0 L of tap water and stirred for 5 minutes to dissolve the inorganic by products. The product was isolated by filtration under reduced pressure and washed with water until the pH is 7. The crude product obtained was air dried overnite to give a semi-dry solid (407 g) which was recrystallized from 1.1 L of ethyl acetate/heptane (1:10 by volume). The product was isolated by filtration (at -8°C), washed with 1.6 L of cold (-10°C) ethyl acetate/heptane (1:10 by volume) and air-dried to give 339 g (88% yield) of BS-2-[Bis(phenylmethyl)amino]benzene-propanol, mp 71.5-73.0°C. More product can be obtained from the mother liquor if necessary. The other analytical characterization was identical to compound prepared as described above.

Step C:

A solution of oxalyl chloride (8.4 ml, 0.096 mol) in dichloromethane (240 ml) was cooled to -74°C. A solution of DMSO (12.0 ml, 0.155 mol) in dichloromethane (50 ml) was then slowly added at a rate to maintain the temperature at -74°C (addition time ~1.25 hr). The mixture was stirred for 5 min. followed by addition of a solution of the alcohol (0.074 mol) in 100 ml of dichloromethane (addition time ~20 min., temp. -75°C to -68°C). The solution was stirred at -78°C for 35 minutes. Triethylamine (41.2 ml, 0.295 mol) was then added over 10 min. (temp. -78° to -68°C) upon which the ammonium salt precipitated. The cold mixture was stirred for 30 min. and then water (225 ml) was added. The dichloromethane layer was separated from the aqueous phase and washed with water, brine, dried over magnesium sulfate, filtered and concentrated. The residue was diluted with ethyl acetate and hexane and then filtered to further remove the ammonium salt. The filtrate was

concentrated to give the desired aldehyde product. The aldehyde was carried on to the next step without purification.

5 Temperatures higher than -70°C have been reported in the literature for the Swern oxidation. Other Swern modifications and alternatives to the Swern oxidations are also possible.

10 Alternatively, the aldehyde was prepared as follows. (200 g, 0.604 mol) was dissolved in triethylamine (300 mL, 2.15 mol). The mixture was cooled to 12°C and a solution of sulfur trioxide/pyridine complex (380 g, 2.39 mol) in DMSO (1.6 L) was added at a rate to maintain the
15 temperature between $8-17^{\circ}\text{C}$ (addition time - 1.0 h). The solution was stirred at ambient temperature under a nitrogen atmosphere for 1.5 hour at which time the reaction was complete by TLC analysis (33% ethyl acetate/hexane, silica gel). The reaction mixture was
20 cooled with ice water and quenched with 1.6 L of cold water ($10-15^{\circ}\text{C}$) over 45 minutes. The resultant solution was extracted with ethyl acetate (2.0 L), washed with 5% citric acid (2.0 L), and brine (2.2 L), dried over MgSO_4 (280 g) and filtered. The solvent was removed on a
25 rotary evaporator at $35-40^{\circ}\text{C}$ and then dried under vacuum to give 198.8 g of α S-[Bis-(phenylmethyl)amino]-benzenepropanaldehyde as a pale yellow oil (99.9%). The crude product obtained was pure enough to be used directly in the next step without purification. The
30 analytical data of the compound were consistent with the published literature. $[\alpha]_{\text{D}25} = -92.9^{\circ}$ (c 1.87, CH_2Cl_2); ^1H NMR (400 MHz, CDCl_3) δ , 2.94 and 3.15 (ABX-System, 2H, $J_{\text{AB}} = 13.9$ Hz, $J_{\text{AX}} = 7.3$ Hz and $J_{\text{BX}} = 6.2$ Hz), 3.56 (t, 1H, 7.1 Hz), 3.69 and 3.82 (AB-System, 4H, $J_{\text{AB}} = 13.7$
35 Hz), 7.25 (m, 15 H) and 9.72 (s, 1H); HRMS calcd for (M+1) $\text{C}_{23}\text{H}_{24}\text{NO}$ 330.450, found: 330.1836. Anal. Calcd. for $\text{C}_{23}\text{H}_{23}\text{ON}$: C, 83.86; H, 7.04; N, 4.25. Found: C, 83.64; H,

7.42; N, 4.19. HPLC on chiral stationary phase: (S,S) Pirkle-Whelk-O 1 column (250 x 4.6 mm I.D.), mobile phase: hexane/isopropanol (99.5:0.5, v/v), flow-rate: 1.5 ml/min, detection with UV detector at 210nm. Retention
5 time of the desired S-isomer: 8.75 min., retention time of the R-enantiomer 10.62 min.

Step D:

A solution of α S-[Bis(phenylmethyl)amino] benzene-propanaldehyde (191.7 g, 0.58 mol) and
10 chloriodomethane (56.4 mL, 0.77 mol) in tetrahydrofuran (1.8 L) was cooled to -30 to -35°C (colder temperature such as -70°C also worked well but warmer temperatures are more readily achieved in large
15 scale operations) in a stainless steel reactor under a nitrogen atmosphere. A solution of n-butyllithium in hexane (1.6 M, 365 mL, 0.58 mol) was then added at a rate that maintained the temperature below -25°C. After addition the mixture was stirred at -30 to -35°C
20 for 10 minutes. More additions of reagents were carried out in the following manner: (1) additional chloriodomethane (17 mL) was added, followed by n-butyllithium (110 mL) at < -25°C. After addition the mixture was stirred at -30 to -35°C for 10
25 minutes. This was repeated once. (2) Additional chloriodomethane (8.5 mL, 0.11 mol) was added, followed by n-butyllithium (55 mL, 0.088 mol) at < -25°C. After addition, the mixture was stirred at -30 to -35°C for 10 minutes. This was repeated 5
30 times. (3) Additional chloriodomethane (8.5 mL, 0.11 mol) was added, followed by n-butyllithium (37 mL, 0.059 mol) at < -25°C. After addition, the mixture was stirred at -30 to -35°C for 10 minutes. This was repeated once. The external cooling was stopped and
35 the mixture warmed to ambient temp. over 4 to 16 hours when TLC (silica gel, 20% ethyl acetate/hexane) indicated that the reaction was completed. The

reaction mixture was cooled to 10°C and quenched with 1452 g of 16% ammonium chloride solution (prepared by dissolving 232 g of ammonium chloride in 1220 mL of water), keeping the temperature below 23°C. The mixture was stirred for 10 minutes and the organic and aqueous layers were separated. The aqueous phase was extracted with ethyl acetate (2x 500 mL). The ethyl acetate layer was combined with the tetrahydrofuran layer. The combined solution was dried over magnesium sulfate (220 g), filtered and concentrated on a rotary evaporator at 65°C. The brown oil residue was dried at 70°C in vacuo (0.8 bar) for 1 h to give 222.8 g of crude material. (The crude product weight was >100%. Due to the relative instability of the product on silica gel, the crude product is usually used directly in the next step without purification). The diastereomeric ratio of the crude mixture was determined by proton NMR: (2S)/(2R): 86:14. The minor and major epoxide diastereomers were characterized in this mixture by tlc analysis (silica gel, 10% ethyl acetate/hexane), R_f = 0.29 & 0.32, respectively. An analytical sample of each of the diastereomers was obtained by purification on silica-gel chromatography (3% ethyl acetate/hexane) and characterized as follows:

N,N,αS-Tris(phenylmethyl)-2*S*-oxiranemethanamine

¹H NMR (400 MHz, CDCl₃) δ 2.49 and 2.51 (AB-System, 1H, J_{AB} = 2.82), 2.76 and 2.77 (AB-System, 1H, J_{AB} = 4.03), 2.83 (m, 2H), 2.99 & 3.03 (AB-System, 1H, J_{AB} = 10.1 Hz), 3.15 (m, 1H), 3.73 & 3.84 (AB-System, 4H, J_{AB} = 14.00), 7.21 (m, 15H); ¹³C NMR (400 MHz, CDCl₃) δ 139.55, 129.45, 128.42, 128.14, 128.09, 126.84, 125.97, 60.32, 54.23, 52.13, 45.99, 33.76; HRMS calcd for C₂₄H₂₆NO (M+1) 344.477, found 344.2003.

N,N, α S-Tris(phenylmethyl)-2R-oxiranemethanamine

¹H NMR (300 MHz, CDCl₃) δ 2.20 (m, 1H), 2.59 (m, 1H), 2.75 (m, 2H), 2.97 (m, 1H), 3.14 (m, 1H), 3.85 (AB-System, 4H), 7.25 (m, 15H). HPLC on chiral stationary phase: Pirkle-Whelk-O 1 column (250 x 4.6 mm I.D.), mobile phase: hexane/isopropanol (99.5:0.5, v/v), flow-rate: 1.5 ml/min, detection with UV detector at 210nm. Retention time of (8): 9.38 min., retention time of enantiomer of (4): 13.75 min.

Alternatively, a solution of the crude aldehyde 0.074 mol and chloriodomethane (7.0 ml, 0.096 mol) in tetrahydrofuran (285 ml) was cooled to -78°C, under a nitrogen atmosphere. A 1.6 M solution of n-butyllithium in hexane (25 ml, 0.040 mol) was then added at a rate to maintain the temperature at -75°C (addition time - 15 min.). After the first addition, additional chloriodomethane (1.6 ml, 0.022 mol) was added again, followed by n-butyllithium (23 ml, 0.037 mol), keeping the temperature at -75°C. The mixture was stirred for 15 min. Each of the reagents, chloriodomethane (0.70 ml, 0.010 mol) and n-butyllithium (5 ml, 0.008 mol) were added 4 more times over 45 min. at -75°C. The cooling bath was then removed and the solution warmed to 22°C over 1.5 hr. The mixture was poured into 300 ml of saturated aq. ammonium chloride solution. The tetrahydrofuran layer was separated. The aqueous phase was extracted with ethyl acetate (1 x 300 ml). The combined organic layers were washed with brine, dried over magnesium sulfate, filtered and concentrated to give a brown oil (27.4 g). The product could be used in the next step without purification. The desired diastereomer can be

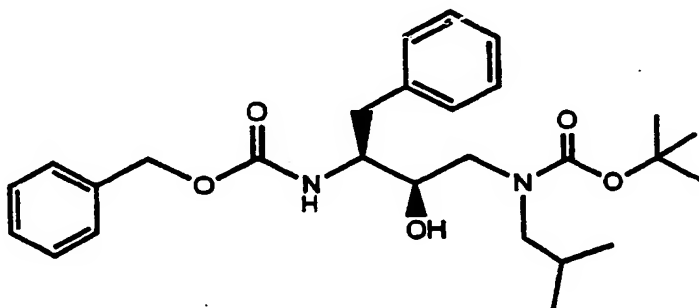
purified by recrystallization at a subsequent step.
The product could also be purified by chromatography.

Alternatively, a solution of α S-

- 5 [Bis(phenylmethyl)amino]benzene-propanaldehyde (178.84 g, 0.54 mol) and bromochloromethane (46 mL, 0.71 mol) in tetrahydrofuran (1.8 L) was cooled to -30 to -35°C (colder temperature such as -70°C also worked well but warmer temperatures are more readily achieved in large
- 10 scale operations) in a stainless steel reactor under a nitrogen atmosphere. A solution of n-butyllithium in hexane (1.6 M, 340 mL, 0.54 mol) was then added at a rate that maintained the temperature below -25°C. After addition the mixture was stirred at -30 to -35°C
- 15 for 10 minutes. More additions of reagents were carried out in the following manner: (1) additional bromochloromethane (14 mL) was added, followed by n-butyllithium (102 mL) at < -25°C. After addition the mixture was stirred at -30 to -35°C for 10
- 20 minutes. This was repeated once. (2) Additional bromochloromethane (7 mL, 0.11 mol) was added, followed by n-butyllithium (51 mL, 0.082 mol) at < -25°C. After addition the mixture was stirred at -30 to -35°C for 10 minutes. This was repeated 5 times.
- 25 (3) Additional bromochloromethane (7 mL, 0.11 mol) was added, followed by n-butyllithium (51 mL, 0.082 mol) at < -25°C. After addition the mixture was stirred at -30 to -35°C for 10 minutes. This was repeated once. The external cooling was stopped and the mixture
- 30 warmed to ambient temp. over 4 to 16 hours when TLC (silica gel, 20% ethyl acetate/hexane) indicated that the reaction was completed. The reaction mixture was cooled to 10°C and quenched with 1452 g of
- 35 16% ammonium chloride solution (prepared by dissolving 232 g of ammonium chloride in 1220 mL of water), keeping the temperature below 23°C. The mixture was stirred for 10 minutes and the organic and aqueous

layers were separated. The aqueous phase was extracted with ethyl acetate (2x 500 mL). The ethyl acetate layer was combined with the tetrahydrofuran layer. The combined solution was dried over magnesium sulfate (220 g), filtered and concentrated on a rotary evaporator at 65°C. The brown oil residue was dried at 70°C in vacuo (0.8 bar) for 1 h to give 222.8 g of crude material.

Example 2

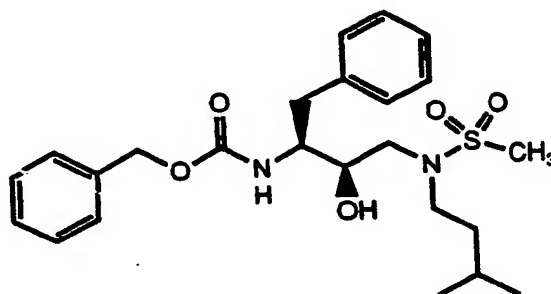


Preparation of N-[[3S-(phenylmethylcarbamoyl)amino]-2R-hydroxy-4-phenyl]-1-[(2-methylpropyl)amino]-2-(1,1-dimethylethoxy)carbonylbutane

To a solution of 7.51g (20.3 mmol) of N-[[3S-(phenylmethylcarbamoyl)amino]-2R-hydroxy-4-phenylbutyl]-N-(2-methylpropyl)amine in 67 mL of anhydrous tetrahydrofuran was added 2.25g (22.3 mmol) of triethylamine. After cooling to 0°C, 4.4g (20.3 mmol) of di-tert-butyl dicarbonate was added and stirring continued at room temperature for 21 hours. The volatiles were removed in vacuo, ethyl acetate added, then washed with 5% citric acid, saturated sodium bicarbonate, brine, dried over magnesium sulfate, filtered and concentrated to afford 9.6g of crude product. Chromatography on silica gel using 30% ethyl acetate/hexane afforded 8.2g of pure N-[[3S-(phenylmethylcarbamoyl)amino]-2R-hydroxy-

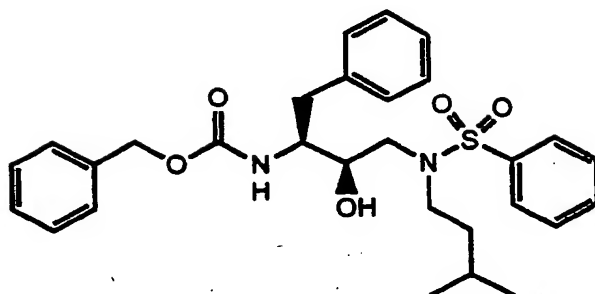
4-phenyl]-1-[(2-methylpropyl)amino-2-(1,1-dimethylethoxyl)carbonyl]butane, mass spectrum $m/e = 477$ ($M+Li$).

5

Example 3A

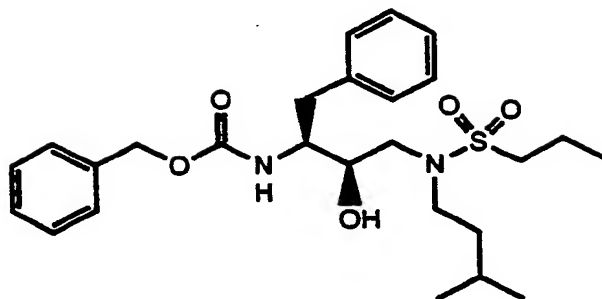
10 Preparation of phenylmethyl [2R-hydroxy-3-[(3-methylbutyl) (methanesulfonyl)amino]-1S-(phenylmethyl)propyl]carbamate

To a solution of N[3(S)-benzyloxycarbonylamino-2(R)-hydroxy-4-phenylbutyl] N-isoamylamine (2.0 gm, 5.2 mmol) and triethylamine (723 μ L, 5.5 mmol) in dichloromethane (20 mL) was added dropwise methanesulfonyl chloride (400 μ L, 5.2 mmol). The reaction mixture was stirred for 2 hours at room temperature, then the dichloromethane solution was concentrated to ca. 5 mL and applied to a silica gel column (100 gm). The column was eluted with chloroform containing 1% ethanol and 1% methanol. The phenylmethyl [2R-hydroxy-3-[(3-methylbutyl) (methanesulfonyl)amino]-1S-(phenylmethyl)propyl]carbamate was obtained as a white solid Anal. Calcd for $C_{24}H_{34}N_2O_5S$: C, 62.31; H, 7.41; N, 6.06. Found: C, 62.17; H, 7.55; N, 5.97.

Example 3B

5 Preparation of phenylmethyl [2R-hydroxy-3-[(3-
methylbutyl) (phenylsulfonyl)amino]-1S-
(phenylmethyl)propyl]carbamate

From the reaction of N[3(S)-
 10 benzyloxycarbonylamino-2(R)-hydroxy-4-phenylbutyl]
 N-isoamylamine (1.47 gm, 3.8 mmol), triethylamine (528
 uL, 3.8 mmol) and benzenesulfonyl chloride (483 uL, 3.8
 mmol) one obtains phenylmethyl [2R-hydroxy-3-[(3-
 methylbutyl) (phenylsulfonyl)amino]-1S-
 15 (phenylmethyl)propyl]-carbamate. Column chromatography
 on silica gel eluting with chloroform containing 1%
 ethanol afforded the pure product. Anal. Calcd for
 C₂₉H₃₆N₂O₅S: C, 66.39; H, 6.92; N, 5.34. Found: C, 66.37;
 H, 6.93; N, 5.26.

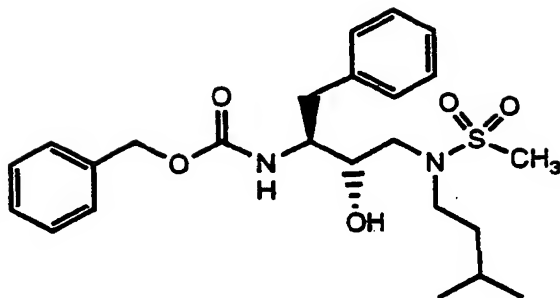
Example 4

5 Preparation of Phenylmethyl [2R-hydroxy-3-[(3-methylbutyl) (n-propanesulfonyl) amino]-1S-(phenylmethyl)propyl]carbamate

10 To a solution of N[3(S)-benzyloxycarbonylamino-2(R)-hydroxy-4-phenylbutyl] N-isoamylamine (192 mg , 0.5 mmol) and triethylamine (139 uL, 1.0 mmol) in dichloromethane (10 mL) was added dropwise trimethylsilyl chloride (63 uL, 0.5 mmol). The reaction was allowed to stir for 1 hour at room temperature, cooled to 0° C with
15 an ice bath and then n-propanesulfonyl chloride (56 uL, 0.5 mmol) was added dropwise. The reaction mixture was stirred for 1.5 hours at room temperature, then diluted with ethyl acetate (50 mL) and washed sequentially with 1N HCl, water, saturated sodium bicarbonate solution, and
20 saturated sodium chloride solution (25 mL each). The organic solution was dried over magnesium sulfate, filtered and concentrated to an oil. The oil was stirred with methanol (10 mL) for 16 hours, concentrated and the residue chromatographed on silica gel (50 gm) eluting
25 with 10% ethyl acetate in hexane (450 mL), then with 1:1 ethyl acetate / hexane. The phenylmethyl [2R-hydroxy-3-[(3-methylbutyl) (n-propanesulfonyl) amino]-1S-(phenylmethyl)propyl]carbamate was recrystallized from ethyl ether / hexane to afford a white solid Anal. Calcd.
30 for C₂₆H₃₈N₂O₅S: C, 63.64; H, 7.81; N, 5.71. Found: C, 63.09; H, 7.74; N, 5.64.

Example 5

5



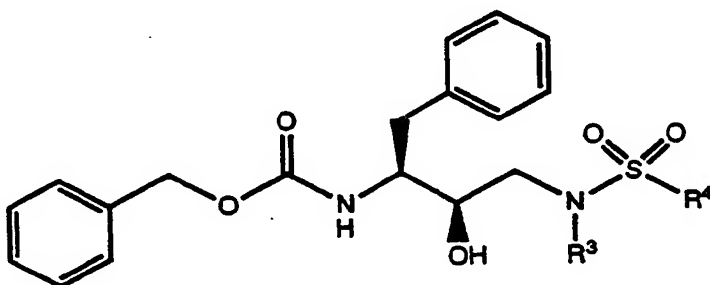
The procedure described in Example 2 was used to prepare
phenylmethyl [2S-hydroxy-3-[(3-methylbutyl)
10 (methanesulfonyl)amino]-1S-(phenylmethyl)propyl]carbamate.

To a solution of N[3(S)-benzyloxycarbonylamino-2(S)-
hydroxy-4-phenylbutyl] N-isoamylamine (192 mg, 0.5 mmol)
and triethylamine (139 μ L, 0.55 mmol) in dichloromethane
15 (8 mL) was added dropwise methanesulfonyl chloride (39
 μ L, 0.55 mmol). The reaction mixture was stirred for 16
hours at room temperature, then the dichloromethane
solution was applied to a silica gel column (50 gm). The
column was eluted with dichloromethane containing 2.5%
20 methanol. The phenylmethyl [2S-hydroxy-3-[(3-
methylbutyl) (methanesulfonyl)amino]-1S-
(phenylmethyl)propyl]carbamate was obtained as a white
solid Anal. Calcd. for $C_{24}H_{34}N_2O_5S \cdot 0.2 H_2O$: C, 61.83;
H, 7.44; N, 6.01. Found: C, 61.62; H, 7.40; N, 5.99.

25

Example 6

Following the procedures of the previous Examples 1-5,
the compounds set forth in Tables 1A and 1B were
5 prepared.

TABLE 1A

10

Entry		R ³	R ⁴
15	1	isoamyl	p-fluorophenyl
	2	isoamyl	p-nitrophenyl
	3	isoamyl	o-nitrophenyl
	4	isoamyl	β-naphthyl
	5	isoamyl	2-thienyl
20	6	isoamyl	benzyl
	7	isobutyl	p-fluorophenyl
	8	p-fluorobenzyl	phenyl
	9	4-pyridylmethyl	phenyl
	10	cyclohexylmethyl	phenyl
25	11	allyl	phenyl
	12	propyl	phenyl
	13	cyclopropylmethyl	phenyl
	14	methyl	phenyl
	15	propargyl	phenyl
30	16	isoamyl	p-chlorophenyl

TABLE 1A (Cont'd)




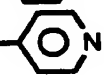
















	Entry	R ³	R ⁴
5	17	isoamyl	p-methoxyphenyl
	18	isoamyl	m-nitrophenyl
	19	isoamyl	m-trifluoromethylphenyl
	20	isoamyl	o-methoxycarbonylphenyl
10	21	isoamyl	p-acetamidophenyl
	22	isobutyl	phenyl
	23	-CH ₂ Ph	-Ph
	24	-CH ₂ - 	-Ph
	25	-CH ₂ - 	-Ph
15	26	-CH ₂ - 	-Ph
	27	-CH ₂ - 	-Ph
	28	-CH ₂ - 	-Ph
	29	-CH ₂ CH=CH ₂	-Ph
	30	- 	-Ph
20	31	- 	-Ph
	32	-CH ₂ CH ₂ Ph	-Ph
	33	-CH ₂ CH ₂ CH ₂ CH ₂ OH	-Ph
	34	-CH ₂ CH ₂ N(CH ₃) ₂	-Ph
	35	-CH ₂ CH ₂ -N 	-Ph
25	36	-CH ₃	-Ph
	37	-CH ₂ CH ₂ CH ₂ SCH ₃	-Ph
	38	-CH ₂ CH ₂ CH ₂ S(O) ₂ CH ₃	-Ph
	39	-CH ₂ CH ₂ CH(CH ₃) ₂	- 
	40	-CH ₂ CH ₂ CH(CH ₃) ₂	-CH ₂ CH ₂ CH ₃

TABLE 1A (Cont'd)

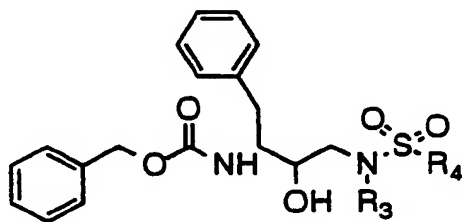
Entry	R ³	R ⁴
5		
41	-CH ₂ CH ₂ CH(CH ₃) ₂	-CH ₃
42	-CH ₂ CH ₂ CH(CH ₃) ₂	-  -F
43	-CH ₂ CH ₂ CH(CH ₃) ₂	-  -CH ₃
44	-CH ₂ CH ₂ CH(CH ₃) ₂	-CO ₂ CH ₃ 
10		
45	-CH ₂ CH(CH ₃) ₂	-  -F
46	-CH ₂ CH(CH ₃) ₂	-  -NHAc
47	-CH ₂ CH(CH ₃) ₂	-  -CH ₃
48	-CH ₂ CH ₂ CH ₃	-  -OCH ₃
49	-CH ₂ CH ₂ CH ₂ CH ₃	-  -OCH ₃
15		
50	-CH ₂ CH ₂ CH(CH ₃) ₂	-CF ₃
51	-CH ₂ CH(CH ₃) ₂	-CH ₃
52	-CH ₂ CH ₂ CH(CH ₃) ₂	-CH ₂ Cl
53	-CH ₂ CH(CH ₃) ₂	-CH ₂ =CH 
54	-CH ₂ CH(CH ₃) ₂	-  -OCH ₃
20		
55	-CH ₂ CH(CH ₃) ₂	-CH=CH ₂
56	-CH ₂ -CH(CH ₃)(CH ₂ CH ₃)	-  -OCH ₃

25

30

TABLE 1A (Cont'd)

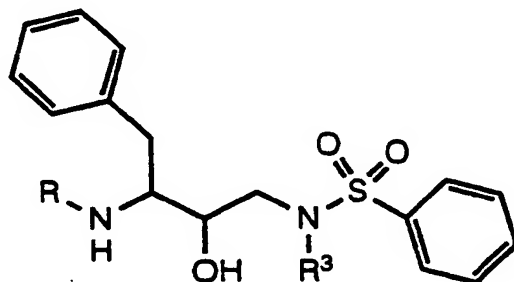
Entry



MASS MEASUREMENT

	R ³	R ⁴	MOL FORM	CALC	FOUND
1			C ₂₉ H ₃₆ N ₂ O ₅ S	531 (M+Li)	531
2			C ₂₉ H ₃₆ N ₂ O ₆ S	541 (M+H)	541
3			C ₃₀ H ₃₆ N ₂ O ₆ S	555.2529 (M+H)	555.2582
4					
5					
6			C ₂₈ H ₃₃ N ₂ O ₅ SF	529.2172 (M+H)	521.2976
7					
8			C ₂₉ H ₃₆ N ₂ O ₅ S ₂	563 (M+Li)	563
9			C ₂₉ H ₃₆ N ₂ O ₆ S ₂	573 (M+H)	573
10			C ₂₉ H ₃₆ N ₂ O ₇ S ₂	595 (M+Li)	595

5

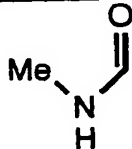
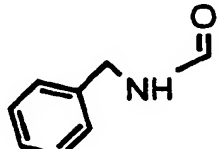
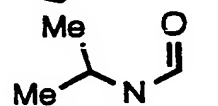
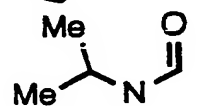
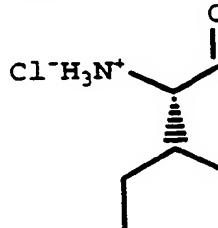
TABLE 1B

5

Entry	R	R ³
1		-CH ₂ Ph
2		-CH ₂ CH ₂ CH(CH ₃) ₂
3		-CH ₂ CH(CH ₃) ₂
4		-CH ₂ CH(CH ₃) ₂
5		-CH ₂ CH(CH ₃) ₂

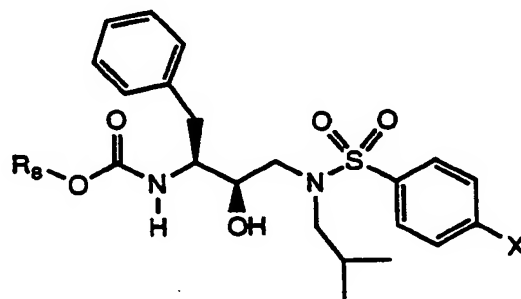
15

TABLE 1B (Cont'd)

Entry	R	R ³
5		
6		-CH ₂ CH(CH ₃) ₂
7		-CH ₂ CH(CH ₃) ₂
8		-CH ₂ CH(CH ₃) ₂
9		-CH ₂ CH ₂ (CH ₃) ₂

10

Table 1C



X	R ⁸	FORMULA	Mass Determination	
			Calc	Found

H.		C ₂₇ H ₃₃ N ₃ O ₅ S	512.2219(M+H)	521.2267
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OCH ₃		C ₂₈ H ₃₅ N ₃ O ₆ S	548.2407(M+Li)	548.2434
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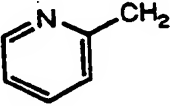
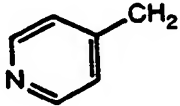
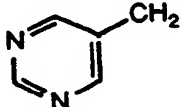
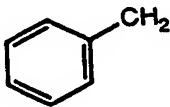
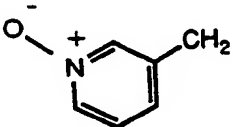
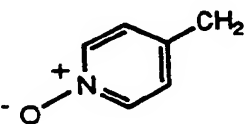
F		C ₂₇ H ₃₂ N ₃ O ₅ SF	530(M+H)	530
---	--	--	----------	-----

Cl		C ₂₇ H ₃₂ N ₃ O ₅ SCl	546(M+H)	546
----	--	---	----------	-----

NO ₂		C ₂₇ H ₃₂ N ₄ O ₇ S	557(M+H)	557
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OH		C ₂₇ H ₃₃ N ₃ O ₆ S	528(M+H)	528
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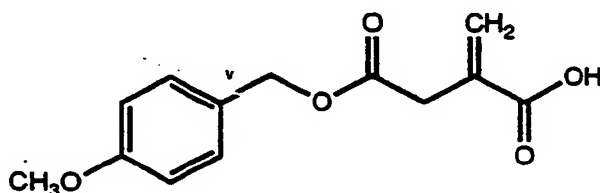
TABLE 1C (Cont'd)

X	R ⁸	FORMULA	Mass Determination	
			Calc	Found
5				
OCH ₃		C ₂₈ H ₃₅ N ₃ O ₆ S	542.2325(M+H)	542.2362
OCH ₃		C ₂₈ H ₃₅ N ₃ O ₆ S	548.2407(M+Li)	548.2393
OCH ₃		C ₂₈ H ₃₅ N ₃ O ₆ S	543(M+H)	543
OCH ₃		C ₂₉ H ₃₆ O ₆ N ₂ S	547.2454(M+Li)	547.2475
OCH ₃	tert-Butyl	C ₂₆ H ₃₈ N ₂ O ₆ S	513.2611(M+Li)	513.2593
OCH ₃		C ₂₈ H ₃₅ N ₃ O ₇ S	564(M+Li)	564
OCH ₃		C ₂₈ H ₃₅ N ₃ O ₇ S	564(M+Li)	564

The following Examples 7-9 illustrate preparation of β -amino acid intermediates. These intermediates can be coupled to the intermediate compounds of Examples 1-6 to produce inhibitor compounds of the present invention containing β -amino acids.

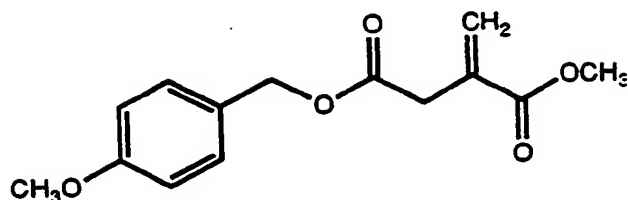
Example 7

A. Preparation of 4(4-methoxybenzyl)itaconate



A 5 L three-necked round bottomed flask equipped with constant pressure addition funnel, reflux condenser, nitrogen inlet, and mechanical stirrer was charged with itaconic anhydride (660.8g, 5.88 mol) and toluene (2300 mL). The solution was warmed to reflux and treated with 4-methoxybenzyl alcohol (812.4g, 5.88 mol) dropwise over a 2.6h period. The solution was maintained at reflux for an additional 1.5h and then the contents were poured into three 2 L erlenmeyer flasks to crystallize. The solution was allowed to cool to room temperature whereupon the desired mono-ester crystallized. The product was isolated by filtration on a Buchner funnel and air dried to give 850.2g, 58% of material with mp 83-85°C, a second crop, 17% was isolated after cooling of the filtrate in an ice bath. ^1H NMR (CDCl_3) 300 MHz 7.32(d, $J=8.7$ Hz, 2H), 6.91(d, $J=8.7$ Hz, 2H), 6.49(s, 1H), 5.85(s, 1H), 5.12(s, 2H), 3.83(s, 3H), 3.40(s, 2H).

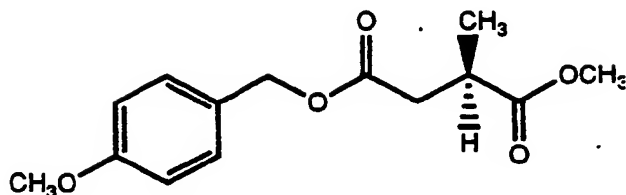
B. Preparation of Methyl 4(4-methoxybenzyl) itaconate



5 A 5 L three-necked round bottomed flask equipped with reflux condenser, nitrogen inlet, constant pressure addition funnel and mechanical stirrer was charged with 4(4-methoxybenzyl) itaconate (453.4g, 1.81 mol) and treated with 1,5-diazabicyclo[4.3.0]non-5-ene
10 (275.6g, 1.81 mol), (DBN), dropwise so that the temperature did not rise above 15°C. To this stirring mixture was added a solution of methyl iodide (256.9g, 1.81 mol) in 250 mL of toluene from the dropping funnel over a 45m period. The solution was allowed to warm to
15 room temperature and stirred for an additional 3.25h.

The precipitated DBN hydroiodide was removed by filtration, washed with toluene and the filtrate poured into a separatory funnel. The solution was washed with
20 sat. aq. NaHCO₃ (2 X 500 mL), 0.2N HCl (1 X 500 mL), and brine (2 X 500 mL), dried over anhyd. MgSO₄, filtered, and the solvent removed in vacuo. This gave a clear colorless oil, 450.2g, 94% whose NMR was consistent with the assigned structure. ¹H NMR (CDCl₃) 300 MHz 7.30(d,
25 J=8.7 Hz, 2H), 6.90(d, J=8.7 Hz, 2H), 6.34(s, 1H), 5.71(s, 1H), 5.09(s, 2H), 3.82(s, 3H), 3.73(s, 3H), 3.38(s, 2H). ¹³C NMR (CDCl₃) 170.46, 166.47, 159.51, 133.55, 129.97, 128.45, 127.72, 113.77, 66.36, 55.12, 51.94, 37.64.

C. Preparation of Methyl 4(4-methoxybenzyl) 2(R)-methylsuccinate



5

A 500 mL Fisher-Porter bottle was charged with methyl 4(4-methoxybenzyl) itaconate (71.1g, 0.269 mol), rhodium (R,R) DiPAMP catalyst (204mg, 0.269 mmol, 0.1 mol%) and degassed methanol (215 mL). The bottle was
10 flushed 5 times with nitrogen and 5 times with hydrogen to a final pressure of 40 psig. The hydrogenation commenced immediately and after ca. 1h the uptake began to taper off, after 3h the hydrogen uptake ceased and the bottle was flushed with nitrogen, opened and the contents
15 concentrated on a rotary evaporator to give a brown oil that was taken up in boiling iso-octane (ca. 200 mL, this was repeated twice), filtered through a pad of celite and the filtrate concentrated in vacuo to give 66.6g, 93% of a clear colorless oil, ¹H NMR (CDCl₃ 300 MHz 7.30(d,
20 J=8.7 Hz, 2H), 6.91(d, J=8.7 Hz, 2H), 5.08(s, 2H), 3.82(s, 3H), 3.67(s, 3H), 2.95(ddq, J=5.7, 7.5, 8.7 Hz, 1H), 2.79(dd, J=8.1, 16.5 Hz, 1H), 2.45(dd, J=5.7, 16.5 Hz, 1H), 1.23(d, J=7.5 Hz, 3H).

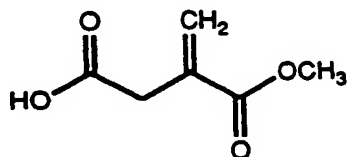
25 D. Preparation of Methyl 2(R)-methylsuccinate

A 3 L three-necked round-bottomed flask equipped with a nitrogen inlet, mechanical stirrer, reflux condenser and constant pressure addition funnel
30 was charged with methyl 4(4-methoxybenzyl) 2(R)-methylsuccinate (432.6g, 1.65 mol) and toluene (1200 mL). The stirrer was started and the solution treated with trifluoroacetic acid (600 mL) from the dropping funnel over 0.25h. The solution turned a deep purple color and
35 the internal temperature rose to 45°C. After stirring

for 2.25h the temperature was 27°C and the solution had acquired a pink color. The solution was concentrated on a rotary evaporator. The residue was diluted with water (2200 mL) and sat. aq. NaHCO₃ (1000 mL). Additional
5 NaHCO₃ was added until the acid had been neutralized. The aqueous phase was extracted with ethyl acetate (2 X 1000 mL) to remove the by-products and the aqueous layer was acidified to pH=1.8 with conc. HCl. This solution
10 was extracted with ethyl acetate (4 X 1000 mL), washed with brine, dried over anhyd. MgSO₄, filtered and concentrated on a rotary evaporator to give a colorless liquid 251g, >100% that was vacuum distilled through a short path apparatus cut 1: bath temperature 120°C @ >1mm, bp 25-29°C; cut 2: bath temperature 140°C @ 0.5mm,
15 bp 95-108°C, 151g, $[\alpha]_D^{25} = +1.38^\circ$ (c=15.475, MeOH), $[\alpha]_D^{25} = +8.48^\circ$ (neat); cut 3: bath temperature 140°C, bp 108°C, 36g, $[\alpha]_D^{25} = +1.49^\circ$ (c=15.00, MeOH), $[\alpha]_D^{25} = +8.98^\circ$ (neat). Cuts 2 and 3 were combined to give 189g, 78% of product, ¹H NMR (CDCl₃) 300 MHz 11.6(brs, 1H), 3.72(s, 3H), 2.92(ddq, J=5.7, 6.9, 8.0 Hz, 1H), 2.81(dd, J=8.0, 16.8 Hz, 1H), 2.47(dd, J=5.7, 16.8 Hz, 1H), 1.26(d, J=6.9 Hz, 3H).

E. Preparation of Methyl Itaconate

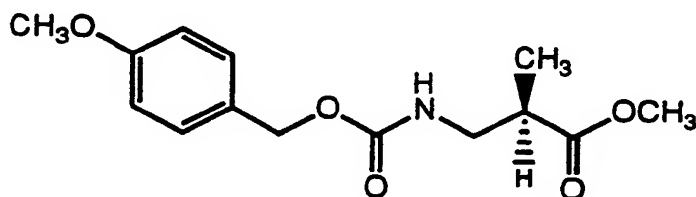
25



A 50 mL round bottomed flask equipped with reflux condenser, nitrogen inlet and magnetic stir bar
30 was charged with methyl 4(4-methoxybenzyl) itaconate (4.00g, 16 mmol), 12 mL of toluene and 6 mL of trifluoroacetic acid. The solution was kept at room temperature for 18 hours and then the volatiles were removed in vacuo. The residue was taken up in ethyl
35 acetate and extracted three times with saturated aqueous

sodium bicarbonate solution. The combined aqueous extract was acidified to pH=1 with aqueous potassium bisulfate and then extracted three times with ethyl acetate. The combined ethyl acetate solution was washed with saturated aqueous sodium chloride, dried over anhydrous magnesium sulfate, filtered, and concentrated in vacuo. The residue was then vacuum distilled to give 1.23g, 75% of pure product, bp 85-87 @ 0.1 mm. ^1H NMR (CDCl_3) 300 MHz 6.34(s, 1H), 5.73(s, 2H), 3.76(s, 3H), 3.38(s, 2H). ^{13}C NMR (CDCl_3) 177.03, 166.65, 129.220, 132.99, 52.27, 37.46.

F. Curtius Rearrangement of Methyl 2(R)-methylsuccinate:
Preparation of Methyl N-Moz- α -methyl β -alanine.

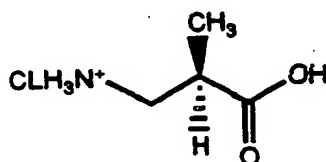


A 5L four necked round bottomed flask equipped with a nitrogen inlet, reflux condenser, mechanical stirrer, constant pressure addition funnel, and thermometer adapter was charged with methyl 2(R)-methylsuccinate (184.1g, 1.26 mol), triethylamine (165.6g, 218 mL, 1.64 mol, 1.3 equivalents), and toluene (1063 mL). The solution was warmed to 85°C and then treated dropwise with a solution of diphenylphosphoryl azide (346.8g, 1.26 mol) over a period of 1.2h. The solution was maintained at that temperature for an additional 1.0h and then the mixture was treated with 4-methoxybenzyl alcohol (174.1g, 1.26 mol) over a 0.33h period from the dropping funnel. The solution was stirred at 88°C for an additional 2.25h and then cooled to room temperature. The contents of the flask were poured into a separatory funnel and washed with sat. aq. NaHCO_3 (2 X 500 mL), 0.2N HCl (2 X 500 mL), brine (1 X

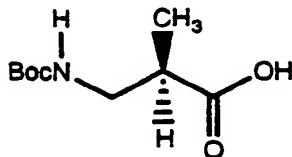
500 mL), dried over anhyd. MgSO_4 , filtered, and concentrated in vacuo to give 302.3g, 85% of the desired product as a slightly brown oil. ^1H NMR (CDCl_3) 300 MHz
7.32(d, $J=8.4$ Hz, 2H), 6.91(d, $J=8.4$ Hz, 2H), 5.2(brm,
5 1H), 5.05(s, 2H), 3.83(s, 3H), 3.70(s, 3H), 3.35(m, 2H),
2.70(m, 2H), 1.20(d, $J=7.2$ Hz, 3H).

G. Hydrolysis of Methyl N-Moz- α -methyl β -alanine:
Preparation of α -methyl β -alanine Hydrochloride

10



A 5 L three-necked round bottomed flask equipped with a reflux condenser, nitrogen inlet and
15 mechanical stirrer was charged with methyl N-Moz- α -methyl β -alanine (218.6g, 0.78 mol), glacial acetic acid (975 mL) and 12N hydrochloric acid (1960 mL). The solution was then heated to reflux for 3h. After the solution had cooled to room temperature (ca. 1h) the aqueous phase was
20 decanted from organic residue (polymer) and the aqueous phase concentrated on a rotary evaporator. Upon addition of acetone to the concentrated residue a slightly yellow solid formed that was slurried with acetone and the white solid was isolated by filtration on a Buchner funnel.
25 The last traces of acetone were removed by evacuation to give 97.7g, 90% of pure product, mp 128.5-130.5°C $[\alpha]_D^{25} = 9.0^\circ\text{C}$ ($c=2.535$, Methanol). ^1H NMR (D_2O) 300 MHz
3.29(dd, $J=8.6, 13.0$ Hz, 1H), 3.16(dd, $J=5.0, 13.0$ Hz, 1H), 2.94(ddq, $J=7.2, 5.0, 8.6$ Hz, 1H), 1.30(d, $J=7.2$ Hz,
30 3H); ^{13}C NMR (D_2O) 180.84, 44.56, 40.27, 17.49.

H. Preparation of N-Boc α -Methyl β -Alanine

5 A solution of α -methyl β -alanine hydrochloride (97.7g, 0.70 mol) in water (1050 mL) and dioxane (1050 mL) the pH was adjusted to 8.9 with 2.9N NaOH solution. This stirring solution was then treated with di-tert-butyl pyrocarbonate (183.3g, 0.84 mol, 1.2 equivalents)

10 all at once. The pH of the solution was maintained between 8.7 and 9.0 by the periodic addition of 2.5N NaOH solution. After 2.5h the pH had stabilized and the reaction was judged to be complete. The solution was concentrated on a rotary evaporator (the temperature was

15 maintained at $<40^{\circ}\text{C}$). The excess di-tert -butyl pyrocarbonate was removed by extraction with dichloromethane and then the aqueous solution was acidified with cold 1N HCl and immediately extracted with ethyl acetate (4 X 1000 mL). The combined ethyl acetate

20 extract was washed with brine, dried over anhyd. MgSO_4 , filtered and concentrated on a rotary evaporator to give a thick oil 127.3g, 90% crude yield that was stirred with n-hexane whereupon crystals of pure product formed, 95.65g, 67%, mp $76-78^{\circ}\text{C}$, $[\alpha]_D^{25} = -11.8^{\circ}$ ($c=2.4$,

25 EtOH). A second crop was obtained by concentration of the filtrate and dilution with hexane, 15.4g, for a combined yield of 111.05g, 78%. ^1H NMR (acetone D_6) 300 MHz 11.7 (brs, 1H), 6.05 (brs 1H), 3.35 (m, 1H), 3.22 (m, 1H), 2.50 (m, 1H), 1.45(s, 9H), 1.19 (d, $J=7.3$ Hz, 3H);

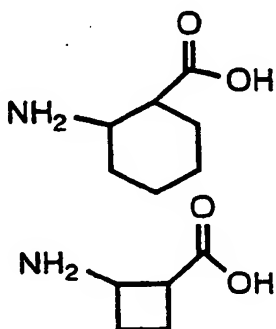
30 ^{13}C NMR (acetone D_6) 177.01, 79.28, 44.44, 40.92, 29.08, 15.50. Elemental analysis calc'd. for $\text{C}_9\text{H}_{17}\text{NO}_4$: C, 53.19, H, 8.42; N, 6.89. Found: C, 53.36; H, 8.46; N, 6.99.

I. Preparation of N-4-Methoxybenzyloxycarbonyl α -Methyl β -Alanine

A solution of N-4-methoxybenzyloxycarbonyl α -methyl β -alanine methyl ester (2.81g, 10.0 mmol) in 30 mL of 25% aqueous methanol was treated with lithium hydroxide (1.3 equivalents) at room temperature for a period of 2h. The solution was concentrated in vacuo and the residue taken up in a mixture of water and ether and the phases separated and the organic phase discarded. The aqueous phase was acidified with aqueous potassium hydrogen sulfate to pH=1.5 and then extracted three times with ether. The combined ethereal phase was washed with saturated aqueous sodium chloride solution, dried over anhydrous magnesium sulfate, filtered and concentrated in vacuo to give 2.60 g, 97% of N-4-Methoxybenzyloxycarbonyl α -methyl β -alanine (N-Moz-AMBA) which was purified by recrystallization from a mixture of ethyl acetate and hexane to give 2.44g, 91% of pure product, mp 96-97°C, $MH^+=268$. 1H NMR (D_6 -acetone/300 MHz) 1.16 (3H, d, $J=7.2Hz$), 2.70 (1H, m), 3.31 (2H, m), 3.31 (3H, s), 4.99 (2H, s), 6.92 (2H, d, $J=8.7 Hz$), 7.13 (2H, d, $J=8.7 Hz$).

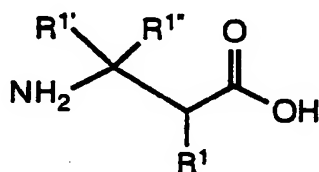
Example 8

Utilizing generally the procedure set forth in Example 7, the following β -amino acid compounds were prepared.



Example 9

Following generally the procedure of Example 7, the β -amino acids set forth in Table 2 were prepared.

Table 2

10







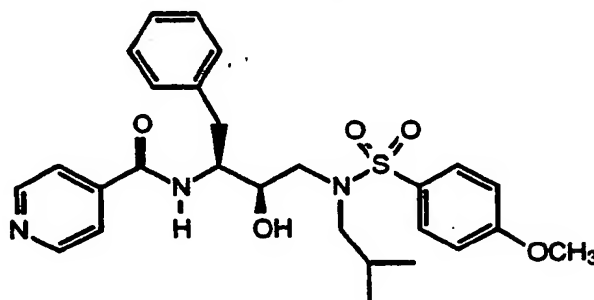
Entry	R ¹	R ^{1'}	R ^{1''}
1	-CH ₃	H	H
15 2	-CH(CH ₃) ₂	H	H
3	-C(CH ₃) ₃	H	H
4	H	H	H
5	H	-CH ₃	H
6	H	-CH ₃	-CH ₃
20 7	H	H	-CO ₂ CH ₃
8	H	H	-CONH ₂
9	-CH ₂ CH ₃	H	H
10	-CH ₂ CH(CH ₃) ₂	H	H
11	-CH ₂ C ₆ H ₅	H	H
25 12	-CH ₂ - 	H	H
13	-CH ₂ - 	H	H
14	-CH ₂ COOH	H	H
15	H	-CH(CH ₃) ₂	H
16	H	-CH ₂ CH(CH ₃) ₂	H
30 17	H	-CH ₂ - 	H

Table 2 (Cont'd)

Entry	R ¹	R ^{1'}	R ^{1''}
18	H	-CH ₂ CH ₂ - 	H
19	H	-(CH ₂) ₃ - 	H
20	H	-(CH ₂) ₄ - 	H
21	H	-(CH ₂) ₃ CH(C ₆ H ₅) ₂	H

Example 10APreparation of 4-Pyridinecarboxamide.

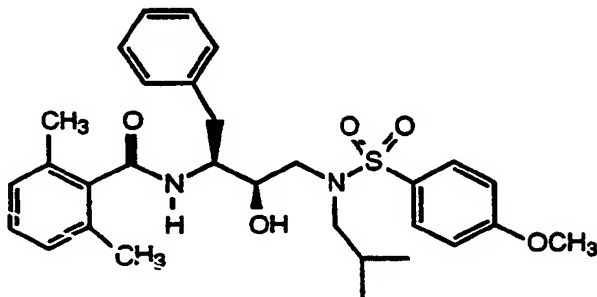
N-[(2R-hydroxy-3-[[[(4-methoxyphenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]]

To a solution of 231 mg (0.57 mmol) of 2R-hydroxy-3-[(2-methylpropyl)(4-methoxyphenyl)sulfonyl]amino-1S-(phenylmethyl)propylamine in 3 mL of methylene chloride at 0 °C, was added 288 mg (2.85 mmol) of triethylamine and then 112 mg (0.63 mmol) of isonicotinoyl chloride hydrochloride. After 19 hours at room temperature, the solvent was removed, ethyl acetate added, then washed with saturated sodium bicarbonate, brine, dried with magnesium sulfate, filtered and concentrated to afford 290 mg of crude product. This was chromatographed on silica gel using 3-5% isopropanol/methylene chloride as eluent to afford 190 mg

of the desired compound; mass spectrum calc. for $C_{27}H_{34}N_3O_5S$ (M + H) 512.2219; found 512.2280.

Example 10B

5



Preparation of Benzamide.

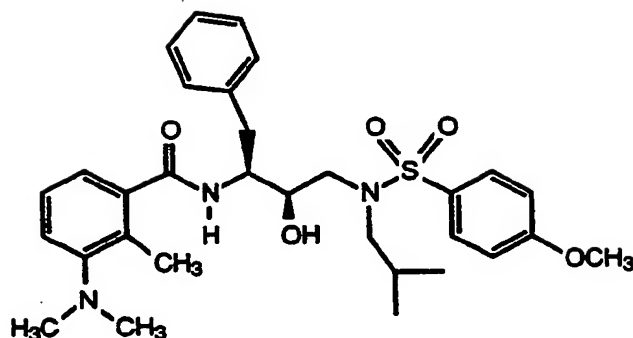
10 N-[2R-hydroxy-3-[[[(4-methoxyphenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-2,6-dimethyl

To a solution of 83 mg (0.55 mmol) of 2,6-dimethylbenzoic acid and 125 mg (0.82 mmol) of N-hydroxybenzotriazole in 3 mL of anhydrous DMF at 0 °C was added 117 mg (0.61 mmol) of 1-(3-dimethylaminopropyl)-3-ethylcarbodiimide hydrochloride. After 2 hours at 0 °C, 203 mg (0.50 mmol) of 2R-hydroxy-3-[(2-methylpropyl)(4-methoxyphenyl)sulfonyl]amino-1S-(phenylmethyl)propylamine was added. After 22 hours at room temperature, the solvent was removed in vacuo, ethyl acetate added, then washed with saturated sodium bicarbonate, brine, dried over magnesium sulfate, filtered and concentrated to afford 300 mg of crude product. Chromatography on silica gel using 20-50% ethyl acetate/hexane afforded 37 mg of the desired product; mass spectrum calcd for $C_{30}H_{38}N_2O_5S$ (M+H) 539.2580; found 539.2632.

15

20

25

Example 10C

5 Preparation of Benzamide, N-[2R-hydroxy-3-[[[4-methoxyphenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-2-methyl.

Part A. Preparation of 4-Nitro-2-methylbenzoic Acid.

10

A mixture of 1.0 g (3.8 mmol) of 2-iodo-nitrotoluene, 2.1 g (15.2 mmol) potassium carbonate and 27 mg (0.038 mmol) of palladium(II) dichloride bis(triphenylphosphine) in a mixture of 5mL of water and 10 mL of N,N-

15 dimethylformamide. This was placed in a Fisher/Porter bottle under 15 psig of carbon monoxide and heated at 70°C for 16 hours. The solution became homogeneous when heated. The reaction was cooled, diethyl ether and water was added, the organic layer separated and discarded.

20 The aqueous layer was acidified with 1N hydrochloric acid, extracted with ethyl acetate, washed with water, brine, dried over magnesium sulfate, filtered and concentrated to yield 0.5g of crude material. This dissolved in ethyl acetate, hexane added and the resulting brown solid

25 discarded. The filtrate was concentrated, and then recrystallized from diethyl ether/hexane to afford 215mg of 4-nitro-2-methylbenzoic acid, m/e=182 (M+H).

30 Part B. Preparation of Benzamide, N-[2R-hydroxy-3-[[[4-methoxyphenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-2-methyl-4-nitro.

To a solution of 181mg (1.0mmol) of 4-nitro-2-methylbenzoic acid and 230mg(1.5mmol) N-hydroxybenzotriazole in 3mL of anhydrous N,N-dimethylformamide at 0°C, was added 211mg(1.1mmol) of 1-(3-dimethylaminopropyl)-3-ethylcarbodiimide hydrochloride. After stirring at 0 C for 1 hour, 406mg (1mmol) of 2R-hydroxy-3-[(2-methylpropyl)(4-methoxyphenyl)sulfonyl]amino-1S-(phenylmethyl)propylamine was added. After 17 hours at room temperature, the solvent was removed under reduced pressure, ethyl acetate added, washed with 5% citric acid, saturated sodium bicarbonate, brine, dried with magnesium sulfate, filtered and concentrated to yield 0.55g of crude product. This was chromatographed on silica gel using 20-50% ethyl acetate/hexane as eluent to afford 0.49g of the desired benzamide, N-[2R-hydroxy-3-[(4-methoxyphenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-2-methyl-4-nitro, m/e=570 (M+H).

20

Part C. Preparation of Benzamide, N-[2R-hydroxy-3-[(4-methoxyphenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-2-methyl-4-amino.

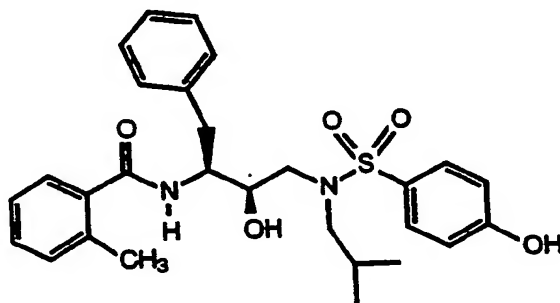
25 A solution of 400mg (0.70mmol) of benzamide, N-[2R-hydroxy-3-[(4-methoxyphenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-2-methyl-4-nitro from part B in 20mL of methanol was hydrogenated over 0.2 g of 10% palladium on carbon catalyst under 50 psig of hydrogen for 2.5 hours. The catalyst was removed by filtration and the solution concentrated to afford 370mg of the desired benzamide, N-[2R-hydroxy-3-[(4-methoxyphenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-2-methyl-4-amino, m/e=540 (M+H).

35

Part D. Preparation of Benzamide, N-[2R-hydroxy-3-[(4-methoxyphenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-2-methyl-4-dimethylamino.

A solution of 0.17g (0.31mmol) of benzamide, N-[2R-hydroxy-3-[[[4-methoxyphenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-2-methyl-4-amino from part C in 5mL of methanol and 0.20mL of 37% aqueous formaldehyde was hydrogenated over 90mg of 10% palladium on carbon under 15psig of hydrogen for 16 hours. The catalyst was removed by filtration, the solvents removed under reduced pressure to afford 0.16g of crude material. Chromatography on silica gel using 50% ethyl acetate as eluent afforded 0.12g of the desired benzamide, N-[2R-hydroxy-3-[[[4-methoxyphenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-2-methyl-4-dimethylamino, m/e=568 (M+H).

Example 10D



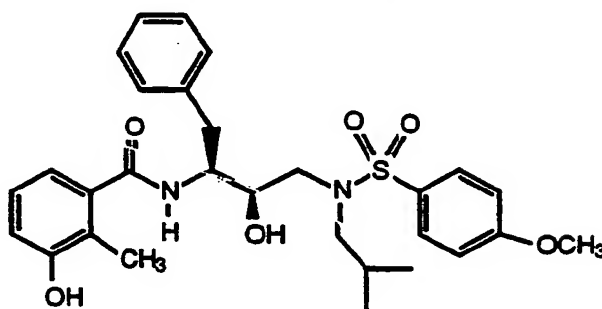
20 Preparation of Benzamide, N-[2R-hydroxy-3-[[[4-hydroxyphenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-2-methyl-

To a solution of 500 mg (1mmol) of 2R-hydroxy-3-[[[2-methylpropyl)(4-hydroxyphenyl)sulfonyl]amino]-1S-(phenylmethyl)propylamine in 2 mL of methylene chloride and 2 mL of N,N-dimethylformamide, was added 0.42 mL of triethylamine, followed by 0.12 mL of ortho-toluoyl chloride. After 17 hours, the solvent was removed under reduced pressure, the residue dissolved in ethyl acetate, was with 5% citric acid, saturated sodium bicarbonate and brine, dried over anhydrous magnesium sulfate, filtered

and concentrated to afford 490 mg of crude material. This was chromatographed over 100g of silica gel using 20-50% ethyl acetate/hexane as eluent to afford 232 mg of the desired product, $m/e=511(M+H)$.

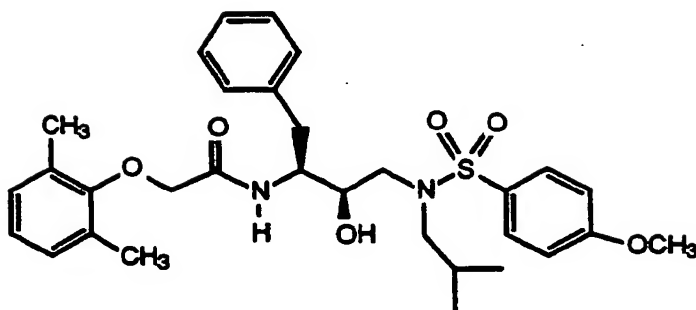
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Example 10E



10 Preparation of Benzamide, N-[2R-hydroxy-3-[[[4-
methoxyphenyl)sulfonyl](2-methylpropyl)amino]-1S-
(phenylmethyl)propyl]-3-hydroxy-2-methyl

To a solution of 131 mg (0.86 mmol) of 3-hydroxy-2-methylbenzoic acid and 305 mg (0.75 mmol) of N-hydroxybenzotriazole in 4 mL of anhydrous N,N-dimethylformamide at 0°C, was added 165 mg (0.86 mmol) of EDC. After 20 minutes of activation at 0°C and 1 hour at room temperature, 305 mg (0.75 mmol) of 2R-hydroxy-3-[(2-methylpropyl)(4-methoxyphenyl)sulfonyl]amino-1S-(phenylmethyl)propylamine was added. After 15 hours at room temperature, ethyl acetate was added, washed with 5% citric acid, saturated sodium bicarbonate, brine, dried, filtered and concentrated to afford 460 mg of crude material. This was chromatographed on silica gel using 0-35% ethyl acetate/methylene chloride as eluent to afford 250 mg of pure benzamide, N-[2R-hydroxy-3-[[[(4-methoxyphenyl)sulfonyl] (2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-3-hydroxy-2-methyl, m/e = 547 (M+Li).

Example 10F

5 Preparation of N-[2R-hydroxy-3-[[[4-methoxyphenyl]
sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-
(2,6-dimethylphenoxy)acetamide

Part A: Preparation of 2,6-Dimethylphenoxyacetic acid

10

2,6-Dimethylphenol (6.1 g, 50.0 mmol), bromoacetic acid (6.9 g, 50.0 mmol) and 2.5 N aqueous sodium hydroxide (50.0 mL, 125.0 mmol) were refluxed in water (125 mL) for 4 hrs. Bromoacetic acid (6.9 g, 50.0 mmol) and 2.5 N aqueous sodium hydroxide (20.0 mL, 62.5 mmol) were added and the solution refluxed for an additional 16 hrs. The solution was cooled to room temperature and water (200 mL) was added. The pH of the solution was adjusted to 1.0 with concentrated aqueous hydrochloric acid. The resulting precipitate was collected and recrystallized from ethyl acetate/hexanes (1:9, 700 mL). 2,6-Dimethylphenoxyacetic acid (4.53 g, 25.1 mmol, 50%) was collected as a white crystalline solid. ¹H NMR (CD₃OD) δ 2.26 (s, 6H), 4.38 (s, 2H), 6.90-7.00 (m, 3H).

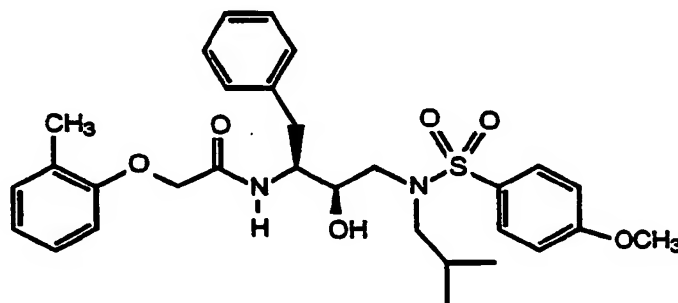
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Part B: Preparation of N-[2R-hydroxy-3-[[[4-methoxyphenyl]sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-(2,6-dimethylphenoxy)acetamide

30 To a solution of 180.1 mg (0.83 mmol) of 2,6-(dimethylphenoxy)acetic acid in 10 mL of anhydrous methylene chloride at room temperature, was added 114 mg

(0.60 mmol) of EDC. After 15 minutes of activation, 203 mg of 2R-hydroxy-3-[[(2-methylpropyl) (4-methoxybenzene) sulfonyl]amino]-1S-(phenylmethyl)propylamine was added. After stirring at room temperature for 16 hours the solution was extracted with 5% citric acid, sodium bicarbonate, brine, dried over magnesium sulfate, filtered and concentrated to afford 244 mg of crude product. A quantity of this (15 mg) was chromatographed on silica gel using 25% ethyl acetate/hexane to afford 8 mg of the desired compound, m/e=575 (M+Li).

Example 10G



15

Preparation of N-[2R-hydroxy-3-[[(4-methoxyphenyl) sulfonyl] (2-methylpropyl) amino]-1S-(phenylmethyl)propyl]- (2-methylphenoxy) acetamide

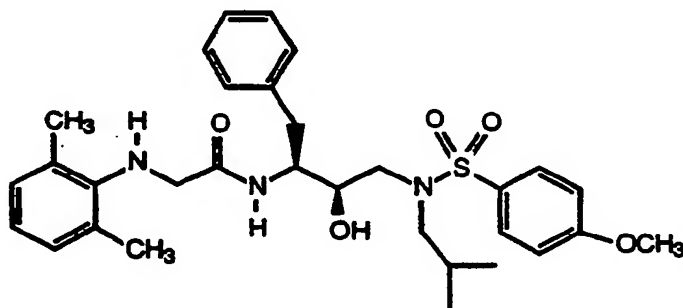
20 Part A: Preparation of 2-Methylphenoxyacetic Acid.

2-Methylphenol (2.0 g, 18.4 mmol), bromoacetic acid (2.5 g, 18.4 mmol) and 2.5 N aqueous sodium hydroxide (25.0 mL, 62.55.0 mmol) refluxed for 16 hrs. The pH of the solution was adjusted to 1 with concentrated aqueous hydrochloric acid. The resulting precipitate was collected triturated with hexanes. The 2-methylphenoxyacetic acid (720 mg, 4.33 mmol, 25%) was collected as a white crystalline solid. ¹HNMR (CD₃OD) δ 2.43 (s, 3H), 4.65 (s, 2H) 6.70-7.10 (m, 4H).

Part B: Preparation of N-[2R-hydroxy-3-[[[4-methoxyphenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-(2-methylphenoxy)acetamide

- 5 To a solution of 97 mg (0.59 mmol) of 2-(methylphenoxy)acetic acid in 5 mL of anhydrous methylene chloride at room temperature, was added 89.1 mg (0.55 mmol) of carbonyl diimidazole. After 15 minutes of activation, 200 mg (0.49 mmol) of 2R-hydroxy-3-[[[2-methylpropyl](4-methoxybenzene)sulfonyl]amino]-1S-(phenylmethyl)propylamine was added. After stirring at room temperature for 15 hours the solution was extracted with 5% citric acid, sodium bicarbonate, brine, dried over magnesium sulfate, filtered and concentrated to afford 15 crude product. This was chromatographed on silica gel using 25% ethyl acetate/hexane to afford 198 mg of the desired compound.

Example 10H



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Preparation of N-[2R-hydroxy-3-[[[4-methoxyphenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-(2,6-dimethylphenyl)acetamide

Part A: Preparation of N-(2,6 Dimethylphenyl)glycine.

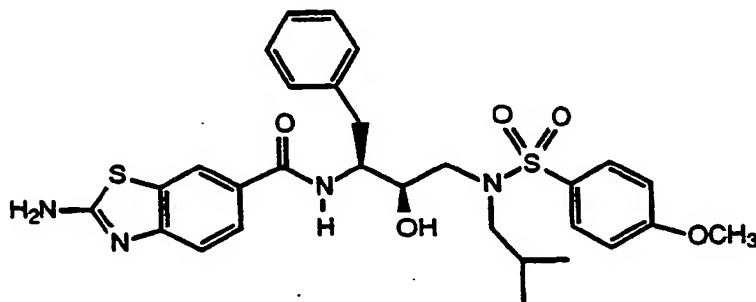
- 2,6-Dimethylaniline (6.1 g, 50.4 mmol), and ethyl bromoacetate (8.4 g, 50.4 mmol) were refluxed neat for 10 min. The reaction mixture was cooled to room temperature and poured into dichloromethane (75 mL). A precipitated

formed which was collected and triturated with dichloromethane (25 mL). N-(2,6-Dimethylphenyl)glycine hydrobromide salt (1.21 g, 4.6 mmol, 9.0%) was collected as a white crystalline solid. ¹H NMR (CD₃OD) δ 2.48 (s, 6H), 4.29 (s, 2H), 7.00-7.10 (m, 3H).

Part B: Preparation of N-[2R-hydroxy-3-[[[4-methoxyphenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-2-(2,6-dimethylphenylamino) acetamide

To a solution of 100 mg (0.39 mmol) of N-(2,6-dimethylphenyl)glycine hydrobromide and 100 mg of triethylamine in 5 mL of anhydrous methylene chloride at room temperature, was added 74 mg (0.39 mmol) of EDC. After 15 minutes of activation, 157 mg (0.39 mmol) of 2R-hydroxy-3-[[[2-methylpropyl)(4-methoxybenzene)sulfonyl]amino]-1S-(phenylmethyl)propylamine was added. After stirring at room temperature for 4 hours, an additional 100 mg of N-(2,6-dimethylphenyl)glycine and 74 mg of EDC was added. After stirring at room temperature for 16 hours, the solution was extracted with 5% citric acid, sodium bicarbonate, brine, dried over magnesium sulfate, filtered and concentrated to afford 206 mg of crude product. This was purified by chromatography on reverse phase using 20-90% acetonitrile/water (0.05% trifluoroacetic acid) to afford 75 mg of the desired compound, m/e = 568 (M+H).

30

Example 10I

Preparation of N-[2R-hydroxy-3-[[[4-methoxyphenyl]
sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-
2-amino-benzothiazole-6-carboxamide

5

Part A: Preparation of 2-Amino-6-Carboxy-Benzothiazole
Ethyl Ester

A 100 ml round bottom flask equipped with magnetic stir
10 bar and N₂ inlet was charged with 1.0 g of methyl p-
aminobenzoate in 35 mL methanol. The solution was heated
to reflux and 4.0 g of Cu^{II}SO₄ and 5.0 g of KSCN were
added. The reaction mixture was refluxed 2 hours and
then filtered. The filtrate was diluted with 60 mL of
15 water and 20 mL of ethanol and heated to boiling. Upon
cooling 1.15 g (78%) of 2-Amino-6-Carboxy-Benzothiazole
Ethyl Ester was isolated, m/e=223(M+H).

20

Part B: Preparation of 2-Amino-6-Carboxy-Benzothiazole.

A 50 mL round bottom flask equipped with magnetic stir
bar was charged with 250 mg 2-Amino-6-Carboxy-
Benzothiazole Ethyl Ester, 190 mg (4 eq.) LiOH in 3 mL
dioxane and 3 mL water. The slurry was heated to 60°C
25 for 2 hours. After 2 hours the solution was acidified
with 1N HCl and concentrated in vacuo to a light grey
solid which was identified as 2-amino-6-carboxy-
benzothiazole, m/e = 195(M+H). It was used without
further purification.

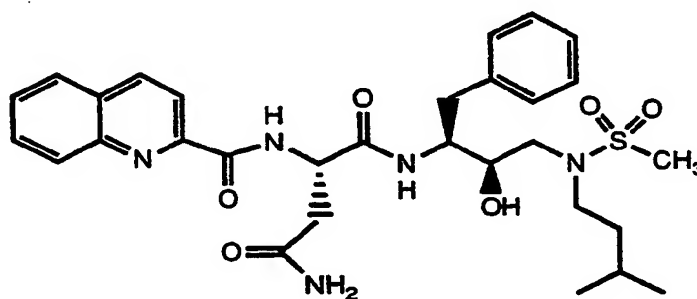
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Part C: Preparation of N-[2R-hydroxy-3-[[[4-
methoxyphenyl) sulfonyl](2-methylpropyl)amino]-1S-
(phenylmethyl)propyl]-2-amino-benzothiazole-6-carboxamide

35 A 100 mL round bottom flask equipped with magnetic stir
bar and N₂ inlet was charged with 110 mg 2-amino-6-
carboxybenzothiazole, 110 mg EDC, and 100 mg HOBt in 4 mL
dry DMF. After 30 minutes activation 203 mg amine (A)

and .5 mL of triethylamine were added and the reaction was stirred overnight. The reaction was partitioned between ethyl acetate and saturated aqueous sodium bicarbonate. The combined organics were washed with 10 % aqueous Citric Acid, water, saturated aqueous sodium bicarbonate, brine and concentrated in vacuo to 210 mg white foam, identified as the desired product, m/e=589 (M+Li)

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Example 11A

Preparation of N1-[2R-hydroxy-3-[(3-methylbutyl)(methylsulfonyl)amino]-1S-(phenylmethyl)propyl]-2S-[2-quinolinylcarbonyl]aminobutanediamide

15

Part A:

A solution of phenylmethyl [2R-hydroxy-3-[(3-methylbutyl)(methylsulfonyl)amino]-1S-(phenylmethyl)-propyl]carbamate prepared as in Example 3 (100 mg) in methanol (10 mL) was hydrogenated over 10% palladium on carbon for 2 hours, filtered through diatomaceous earth and concentrated to give the product as an oil.

25

Part B:

A solution of N-CBZ-L-asparagine (61 mg, 0.23 mmol) and N-hydroxybenzotriazole (33 mg, 0.22 mmol) in DMF (2 mL) was cooled to 0° C with an ice bath and then EDC (42 mg, 0.22 mmol) was added. The solution was stirred for 30 minutes at 0° C and then the product of Part A (69 mg, 0.21 mmol) in DMF (2 mL) was added. After

30

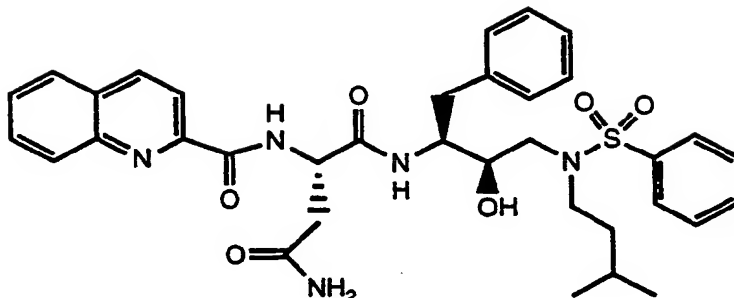
30 minutes at 0° C the reaction was allowed to warm to room temperature and stir for 16 hours. The reaction mixture was then poured into a 50% saturated aqueous solution of sodium bicarbonate (100 mL) and the resulting
5 white precipitate collected by suction filtration, washed with water and dried in vacuo. The phenylmethyl [3-amino-1S-[[2R-hydroxy-3-[(3-methylbutyl) (methylsulfonyl) amino]-1S-(phenylmethyl) amino] carbonyl]-3-oxopropyl] carbamate was obtained as a white solid Anal.
10 Calcd. for C₂₈H₄₀N₄O₇S . 0.5 H₂O: C, 57.42; H, 7.06; N, 9.57. Found: C, 57.72; H, 7.21; N, 9.24.

Part C:

A solution of phenylmethyl [3-amino-1S-[[2R-
15 hydroxy-3-[(3-methylbutyl) (methylsulfonyl) amino]-1S-(phenylmethyl) amino] carbonyl]-3-oxopropyl] carbamate (135 mg, 0.23 mmol) in methanol (15 mL) was hydrogenated over 10% palladium on carbon for 6 hours, filtered through diatomaceous earth and concentrated to give the
20 product as an oil.

Part D:

To a solution of the product from Part C (101 mg, 0.23 mmol) in DMF (5 mL) was added 2-quinoline
25 carboxylic acid N-hydroxysuccinimide ester (67 mg, 0.25 mmol). The reaction was stirred at room temperature for 16 hours, then poured into a 50% saturated solution of sodium bicarbonate (60 mL). The resulting solid was collected by suction filtration washed with water and
30 dried in vacuo. The N1-[2R-hydroxy-3-[(3-methylbutyl) (methylsulfonyl)-amino]-1S-(phenylmethyl) propyl]-2S-[(2-quinolinyl carbonyl)-amino] butanedi amide was obtained as a white solid Anal. Calcd. for C₃₀H₃₉N₅O₆S . 0.1 H₂O: C, 58.52; H, 6.71; N, 11.37. Found: C, 58.34; H, 6.35; N,
35 11.13.

Example 11B

- 5 Preparation of N1-[2R-hydroxy-3-[(3-methylbutyl)
(phenylsulfonyl)amino]-1S-(phenylmethyl)propyl]-2S-[(2-
quinolinylcarbonyl)amino]butanediamide.

Part A:

- 10 The CBZ protected compound phenylmethyl [2R-
 hydroxy-3-[(3-methylbutyl)(phenylsulfonyl)amino]-1S-
 (phenylmethyl)propyl]carbamate (200 mg, 0.38 mmol) was
 deprotected by hydrogenation over 10% palladium on carbon
 and the resulting product obtained as an oil.

Part B:

- 15 The free amine from Part A was coupled with
 N-CBZ-L-asparagine (109 mg, 0.41 mmol) in the presence of
 N-hydroxybenzotriazole (63 mg, 0.41 mmol) and EDC (77 mg,
 20 0.40 mmol) to give phenylmethyl [3-amino-1S-[[2R-hydroxy-
 3-[(3-methylbutyl)(phenylsulfonyl)amino]-1S-
 (phenylmethyl)amino]carbonyl]-3-oxopropyl]carbamate as a
 white solid. Anal. Calcd. for C₃₃H₄₂N₄O₇S: C, 62.05; H,
 6.63; N, 8.77. Found: C, 61.86; H, 6.60; N, 8.64.

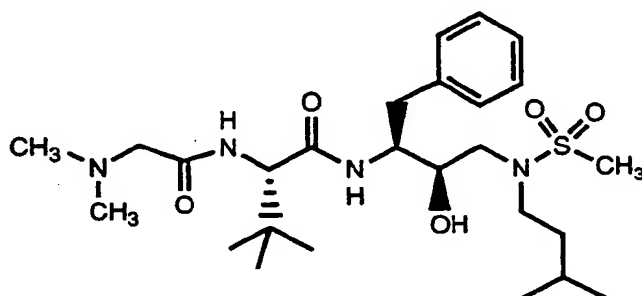
Part C:

- 25 The product of Part B (110 mg, 0.17 mmol) was
 deprotected by hydrogenation over 10% palladium on carbon
 to give the product as an oil.

Part D:

The resulting free amine was coupled with 2-quinoline carboxylic acid N-hydroxysuccinimide ester (45 mg, 0.17 mmol) to give N1- [2R-hydroxy-3-[(3-methylbutyl) (phenylsulfonyl) amino]-1S-(phenylmethyl) propyl]-2S-[(2-quinolinylcarbonyl) amino]butanediamide as a white solid. Anal. Calcd .for C₃₅H₄₁N₅O₆S: C, 63.71; H, 6.26; N, 10.61. Found: C, 63.59; H, 6.42; N, 10.42.

10

Example 12A

Preparation of 2S-[[[(dimethylamino)acetyl]amino]-N-[2R-hydroxy-3-[(3-methylbutyl) (methylsulfonyl) amino]-1S-(phenylmethyl) propyl]-3,3-dimethylbutanamide

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Part A:

To a solution of N-CBZ-L-tert-leucine (100 mg, 0.38 mmol) and N-hydroxybenzotriazole (52 mg, 0.34 mmol) in DMF (3 mL) was added EDC (65 mg, 0.34 mmol). The solution was stirred for 60 minutes at room temperature and then the product of Example 10, Part A (105 mg, 0.32 mmol) in DMF (2 mL) was added. The reaction was stirred for 16 hours at room temperature, then poured into a 50% saturated solution of sodium bicarbonate (50 mL). The aqueous mixture was extracted twice with ethyl acetate (25 mL). The combined ethyl acetate layers were washed with water (25 mL) and dried over magnesium sulfate. Filtration and concentration produced an oil which was chromatographed on silica gel (50 gm) eluting with 2.5 % methanol in dichloromethane. The phenylmethyl [1S-[[[2R-

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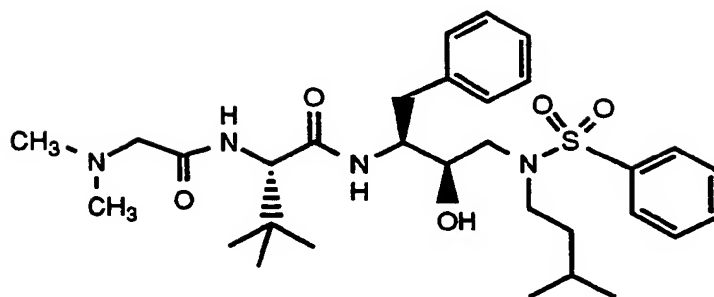
hydroxy-3-[(3-methylbutyl)-(methylsulfonyl)amino]-1S-(phenylmethyl)propyl]amino]-carbonyl]-2,2-dimethylpropyl]carbamate was obtained as a gummy solid
Anal. Calcd. for $C_{30}H_{45}N_3O_6S \cdot 2.2 H_2O$: C, 58.55; H, 8.09; N, 6.83. Found: C, 58.38; H, 7.77; N, 7.10.

Part B:

A solution of phenylmethyl [1S-[[[2R-hydroxy-3-[(3-methylbutyl) (methylsulfonyl)amino]-1S-(phenylmethyl)propyl]amino]carbonyl]-2,2-dimethylpropyl]carbamate (100 mg, 0.17 mmol) in methanol (10 mL) was hydrogenated over 10% palladium on carbon for 2 hours. The reaction was filtered through diatomaceous earth and concentrated to an oil.

Part C:

N,N-dimethylglycine (20 mg, 0.19 mmol), N-hydroxybenzotriazole (28 mg, 0.18 mmol) and EDC (35 mg, 0.18 mmol) were stirred in DMF (4 mL) at room temperature for 40 minutes. The product from Part B in DMF (4 mL) was added and the reaction mixture stirred for 16 hours, then poured into a 50% saturated sodium bicarbonate solution (50 mL). The aqueous mixture was extracted three times with dichloromethane (30 mL) which in turn were washed with water (30 mL) and dried over magnesium sulfate. Filtration and concentration afforded an oil. The oil was chromatographed on silica gel (50 gm) eluting initially with 2.5 % methanol in dichloromethane (400 mL) and then with 5% methanol in dichloromethane. The 2S-[[[(dimethylamino)acetyl]amino]-N-[2R-hydroxy-3-[(3-methylbutyl)(methylsulfonyl)amino]-1S-(phenylmethyl)propyl]-3,3-dimethylbutanamide was obtained as a white solid
Anal. Calcd. for $C_{26}H_{46}N_4O_5S \cdot 0.5 CH_2Cl_2$: C, 56.04; H, 8.34; N, 9.87. Found: C, 56.06; H, 8.36; N, 9.70.

Example 12B

5 Preparation of 2S-[[[(dimethylamino)acetyl]amino]-N-[(2R-hydroxy-3-[(3-methylbutyl)(phenylsulfonyl)amino]-1S-(phenylmethyl)propyl]-3,3-dimethylbutane]amide

Part A:

10

To a solution of N-CBZ-L-tert-leucine (450 mg, 1.7 mmol) and N-hydroxybenzotriazole (260 mg, 1.7 mmol) in DMF (10 mL) was added EDC (307 mg, 1.6 mmol). The solution was stirred for 60 minutes at room temperature and then the product of Example 11, Part A (585 mg, 1.5 mmol) in DMF

(2 mL) was added. The reaction was stirred for 16 hours at room temperature, then poured into a 50% saturated solution of sodium bicarbonate (200 mL). The aqueous mixture was extracted thrice with ethyl acetate (50 mL). The combined ethyl acetate layers were washed with water (50 mL) and saturated NaCl solution (50 mL), then dried over magnesium sulfate. Filtration and concentration produced an oil which was chromatographed on silica gel (50 gm) eluting with 20% ethyl acetate in hexane. The phenylmethyl [1S-[[[2R-hydroxy-3-[(3-methylbutyl)(phenylsulfonyl)amino]-1S-(phenylmethyl)propyl]amino]carbonyl]-2,2-dimethylpropyl]carbamate was obtained as a solid Anal. Calcd for C₃₅H₄₇N₃O₆S: C, 65.91; H, 7.43; N, 6.59. Found: C, 65.42; H, 7.24; N, 6.55.

30

Part B:

A solution of phenylmethyl [1S-[[[2R-hydroxy-3-
[(3-methylbutyl)(phenylsulfonyl)-amino]-1S-
5 (phenylmethyl)propyl]amino]carbonyl]-2,2-
dimethylpropyl]carbamate (200 mg, 0.31 mmol) in methanol
(15 mL) was hydrogenated over 10% palladium on carbon for
2 hours. The reaction was filtered through diatomaceous
earth and concentrated to an oil.

10

Part C:

The resulting free amine from part B (150 mg,
0.3 mmol) was combined with diisopropylethylamine (114
15 uL, 0.33 mmol) in dichloromethane (5 mL). To this was
added bromoacetyl chloride (27 uL, 0.33 mmol) dropwise.
The reaction was stirred for 30 minutes at room
temperature, then diluted with dichloromethane (30 mL)
and extracted with 1 N HCl, water, and then saturated
20 NaCl solution (25 mL each). The organic solution was
dried over MgSO₄ and concentrated to a solid. The 2S-
[[bromoacetyl]amino]-N-[2R-hydroxy-3-[(3-
methylbutyl)(phenylsulfonyl)amino]-1S-
(phenylmethyl)propyl]-3,3-dimethylbutaneamide was
25 sufficiently pure for use in the next step. This
material can also be prepared by substituting bromoacetic
anhydride for bromoacetyl chloride, or one can use
chloroacetyl chloride or chloroacetic anhydride.

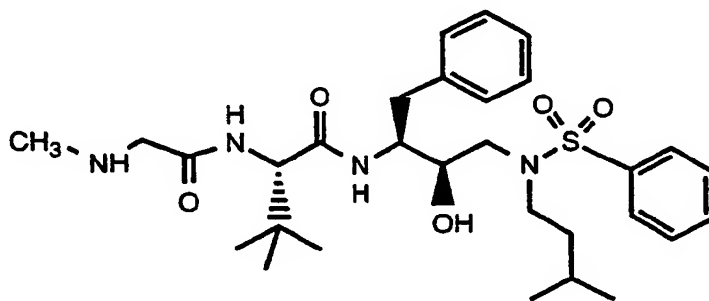
30 Part D:

The product from part C was dissolved in
dichloromethane (5 mL) and diisopropylethylamine (114 uL,
0.66 mmol) and dimethylamine hydrochloride (53 mg, 0.66
35 mmol) were added. The reaction was stirred for 18 hours
then concentrated under a stream of nitrogen to about 1
mL. The residue was chromatographed on silica gel (50
gm) using 2% methanol in dichloromethane. The

2S-[[[(dimethylamino)-acetyl] amino]-N-[2R-hydroxy-3-[(3methylbutyl)-(phenylsulfonyl)amino]-1S-(phenylmethyl)propyl]-3,3-dimethylbutaneamide was obtained as a solid. Anal. Calcd for C₃₁H₄₈N₄O₅S: C, 63.24; H, 8.22; N, 9.52.

5 Found: C, 63.03; H, 8.01; N, 9.40.

Example 12C



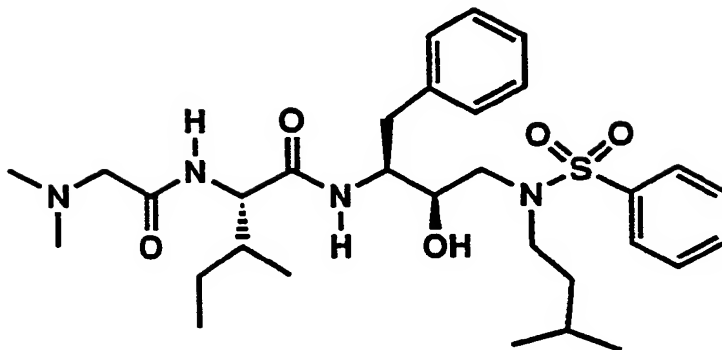
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Preparation of 2S-[[[(methylamino)acetyl]amino]-N-[2R-hydroxy-3-[(3-methylbutyl)(phenylsulfonyl)amino]-1S-(phenylmethyl)propyl]-3,3-dimethylbutaneamide

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2S-[[[bromoacetyl]amino]-N-[2R-hydroxy-3-[(3-methylbutyl)(phenylsulfonyl)amino]-1S-(phenylmethyl)propyl]-3,3-dimethylbutaneamide (103 mg, 0.16 mmol) and 40% aqueous methylamine (42 uL, 0.49 mmol) were combined in ethanol (2 mL) and stirred at room temperature for 24 hours. The reaction mixture was concentrated to dryness and triturated with ether. The solid material was removed by filtration and the filtrate concentrated to an oil. The oil was chromatographed on silica (50 gm) using 4% methanol in dichloromethane. The 2S-[[[(methylamino)acetyl]amino]-N-[2R-hydroxy-3-[(3-methylbutyl)(phenylsulfonyl)amino]-1S-(phenylmethyl)propyl]-3,3-dimethylbutaneamide was obtained as a solid. Anal. Calcd for C₃₀H₄₆N₄O₅S: C, 62.69; H, 8.07; N, 9.75. Found: C, 62.38; H, 8.14; N, 9.60.

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Example 12D

5 Preparation of Pentanamide, 2S-[[[(dimethylamino)acetyl]amino]-N-[2R-hydroxy-3-[(3-methylbutyl)phenylsulfonyl]amino]-1S-(phenylmethyl)propyl]-3-methyl-

Part A:

10 To a solution the amine product of Example 11, Part A; (2.79 g, 7.1 mmol) in 27 mL of dioxane was added (2.3 g, 7.1 mmol) of N-t-butylcarbonyl-L-isoleucine-N-hydroxysuccinamide ester, and the reaction was stirred under nitrogen atmosphere for 16 hours. The contents of

15 the reaction were concentrated in vacuo, and the residue dissolved in ethyl acetate, washed with potassium hydrogen sulfate (5% aqueous), saturated sodium bicarbonate, and saturated sodium chloride. The organic layer was dried over magnesium sulfate, filtered and

20 concentrated to yield 4.3 grams of crude material which was chromatographed using 3:1 ethyl acetate: hexane to obtain 3.05g, 72% yield of Pentanamide, 2S-[[[(1,1-dimethylethoxy)carbonyl]amino]-N-[2R-hydroxy-3-[(3-methylbutyl)phenylsulfonyl]amino]-1S-

25 (phenylmethyl)propyl]-3-methyl-.

Part B

(3.05g, 5.0 mmol) of the product from Part A was dissolved in 20 mL of 4N HCl in dioxane and stirred

30 under nitrogen atmosphere for 1.5 hours. The contents were concentrated in vacuo, and chased with diethyl

ether. The crude hydrochloride salt was pumped on at 1 mm Hg until dry to yield 2.54 g of product as its hydrochloride salt.

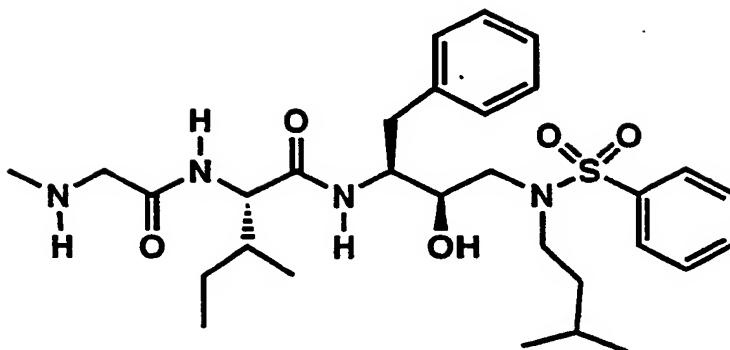
5 Part C:

(2.54 g, 5.0 mmol) of amine hydrochloride was dissolved in 50 mL of tetrahydrofuran and to this was added (1.01 g, 10 mmol) of 4-methyl-morpholine, at which time a precipitate forms. To this suspension was added
10 chloroacetic anhydride (0.865 g, 5.0 mmol) and stirred for 40 minutes. The contents were concentrated in vacuo, and the residue partitioned in ethyl acetate (200 mL) and 5% KHSO₄. The organic layer was washed with saturated sodium bicarbonate, and saturated sodium chloride, dried
15 over magnesium sulfate, filtered and concentrated to yield the crude product. Purification by silica gel chromatography using an eluant of 1:1 ethyl acetate: hexanes yielded 1.89 grams of pure chloroacetamide.

20 Part D:

To a solution of chloroacetamide (1.89 g, 3.2 mmol) from Part C, in 25 mL of tetrahydrofuran was added 4.0 mL of 50% aqueous dimethylamine and the solution was stirred for 1 hour. The solution was concentrated in
25 vacuo and the residue was dissolved in ethyl acetate and washed with water. The organic layer was dried over magnesium sulfate, filtered and concentrated to yield the crude product which was purified by crystallization from ethyl acetate and isooctane to yield 1.80 g, (88% yield),
30 mp. = 121-122 C, HRes. MS. calc. 589.3424, found 589.3405.

100

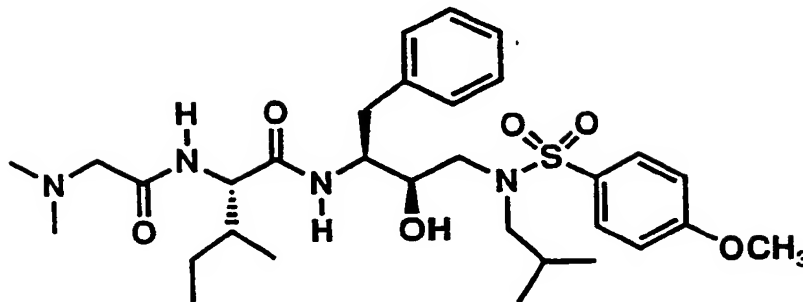
Example 12E

5 Preparation of Pentanamide, 2S-
[[(Methylamino)acetyl]amino]-N-[2R-hydroxy-3-[(3-
methylbutyl) (phenylsulfonyl) amino]-1S-
(phenylmethyl)propyl]-3S-methyl-

10 To a solution of the chloroacetamide of Example
12D, Part C, (2.36 g, 4.0 mmol) in tetrahydrofuran (25
mL) was added 3 mL of aqueous methylamine 40 wt%, and the
reaction stirred for 1 hour. The contents were
concentrated and the residue was partitioned between
15 ethyl acetate (100 mL) and water (100 mL). The organic
layer was dried over magnesium sulfate, filtered and
concentrated to yield the crude product, which was
purified by recrystallization from ethyl acetate heptane;
(M+H)575, HRes.found 575.3267.

20

101

Example 12F

5 Preparation of Pentanamide, 2S-[[[(dimethylamino)acetyl]
aminol-N-[2R-hydroxy-3-[(3-methylpropyl)(4-
methoxyphenylsulfonyl)aminol-1S-(phenylmethyl)
propyl]-3S-methyl-

10 Part A:

To a solution of 2R-hydroxy-3-[(2-methylpropyl)
 (4-methoxyphenylsulfonyl)amino]-1S-(phenylmethyl)
 propylamine (1.70 g, 4.18 mmol) in 40 mL of
 dichloromethane was added N-carbobenzyloxy-L-isoleucine-
 15 N-hydroxysuccinamide ester (1.51 g, 4.18 mmol) and the
 solution stirred under nitrogen atmosphere for 16 hours.
 The contents were concentrated in vacuo and the residue
 was redissolved in ethyl acetate. The ethyl acetate
 solution was washed with an aqueous solution of 5% KHSO₄,
 20 saturated sodium bicarbonate, and saturated sodium
 chloride, dried over magnesium sulfate, filtered, and
 concentrated to yield 2.47g of crude product. The
 product was purified by silica gel chromatography using 1
 2:1 hexane:ethyl acetate eluant to yield 2.3 g. (84%
 25 yield) of 2S-[(carbobenzyloxy)amino]-N-[2R-hydroxy-3-[(3-
 methylpropyl)(4-methoxyphenylsulfonyl)amino]-1S-
 (phenylmethyl)propyl]-3S-methylpentanamide.

Part B:

30 (1.18 g, 1.8 mmol) of the product from Part A
 was dissolved in 50 mL of methanol, and to this was added
 250 mg of 10% Palladium on Carbon while under a stream of

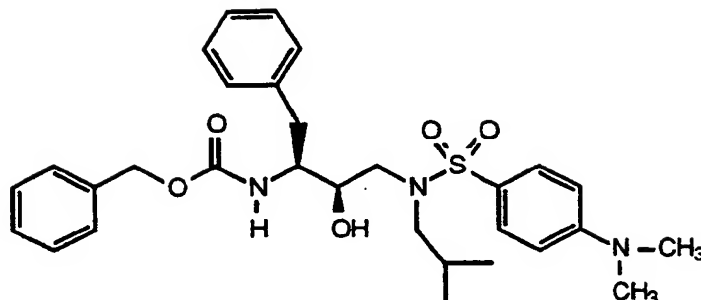
nitrogen. The suspension was hydrogenated using 50 psig of hydrogen for 20 hours. The contents were purged with nitrogen and filtered through celite, and concentrated in vacuo to yield 935 mg of 2S-(amino)-N-[2R-hydroxy-3-[(3-methylpropyl)(4-methoxyphenylsulfonyl) amino]-1S-(phenylmethyl)propyl]-3S-methylpentanamide, which was used without further purification.

Part C:

(0.935 g, 1.8 mmol) of the amine from Part B was dissolved in 15 mL of dioxane and to this was added (190 mg, 1.85 mmol) of 4-methylmorpholine followed by (0.315 g, 1.8 mmol) of chloroacetic anhydride. The reaction mixture was stirred under nitrogen atmosphere for 3 hours, concentrated in vacuo, and redissolved in ethyl acetate. The ethyl acetate solution was washed with 50 mL of 5% aqueous KHSO₄, saturated NaHCO₃, and saturated NaCl solution, dried over MgSO₄, filtered and concentrated to yield 613 mg, (68% yield) of 2S-[(chloroacetyl)amino]-N-[2R-hydroxy-3-[(3-methylpropyl)(4-methoxyphenylsulfonyl)amino]-1S-(phenylmethyl)propyl]-3S-methylpentanamide, after purification by silica gel chromatography using 1:1 hexane:ethyl acetate.

Part D:

To a solution of the chloroacetamide from Part C (673 mg, 1.10 mmol) in 20 mL of tetrahydrofuran was added 5 mL of 50 wt% aqueous dimethylamine and the solution was stirred for 1 hour. The reaction was concentrated and the residue was redissolved in 50 mL of ethyl acetate and washed with 25 mL of water. The ethyl acetate layer was dried over magnesium sulfate, filtered and concentrated to yield a crude solid which was purified by silica gel column chromatography using an eluant of 97:3 dichloromethane:methanol to provide 400 mg of Pentanamide, 2S-[[dimethylamino)acetyl]amino]-N-[2R-hydroxy-3-[(3-methylpropyl)(4-methoxyphenylsulfonyl) amino]-1S-(phenylmethyl)propyl]-3S-methyl-.

Example 13A

5

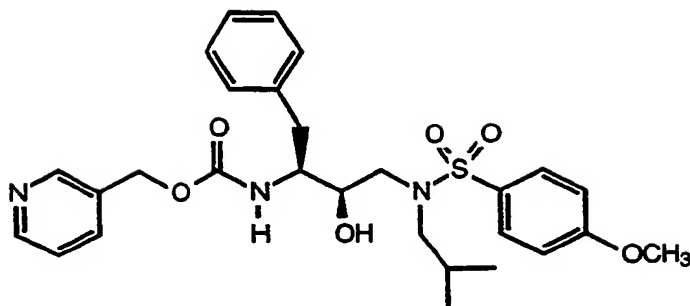
Preparation of Carbamic acid, [2R-hydroxy-3-[[[4-dimethylaminophenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-, phenylmethyl ester

10

To a solution of 100mg (0.19 mmol) of carbamic acid, [2R-hydroxy-3-[[[4-fluorophenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-, phenylmethyl ester in 1 mL of pyridine was added 53 μ L of triethylamine and 120 μ L (p.95 mmol) of 40% aqueous dimethylamine. After heating for 24 hours at 100°C, the solution was cooled, ethyl acetate added, then washed with 5% citric acid, saturated sodium bicarbonate, dried over magnesium sulfate, filtered and concentrated. The resulting solid was recrystallized from ethyl acetate/hexane to afford 10 mg of the desired product; mass spectrum m/e = 540 (M+H).

15

20

Example 13B

- 5 Preparation of Carbamic acid, [2R-hydroxy-3-[[[4-methoxyphenyl)sulfonyl](2-methylpropyl)aminol-1S-(phenylmethyl)propyl]-, 3-pyridylmethyl ester

Part A:

- 10 A solution of N-benzyloxycarbonyl-3S-amino-1,2-S-epoxy-4-phenylbutane (50g, 0.168 mol) and isobutylamine (246g, 3.24 mol) in 650 mL of isopropyl alcohol was refluxed for 1.25 hours. The solution was cooled to room temperature, concentrated in vacuo and then poured into
- 15 1L of stirring hexane whereupon the product crystallized from solution, was collected and air dried to give 57.6 g of N-[3S-benzyloxycarbonylamino-2R-hydroxy-4-phenyl]-N-isobutylamine, mp 108-109.5°C, mass spectrum m/e=371(M+H).

20

Part B:

- The amine from part A (1.11g, 3.0 mmol) and triethylamine (324mg, 3.20 mmol) in 20 mL of methylene chloride was treated with 715 mg (3.46 mmol) of 4-
- 25 methoxybenzenesulfonyl chloride. The solution was stirred at room temperature for 6 hours, concentrated, dissolved in ethyl acetate, then washed with 1N potassium hydrogen sulfate, saturated sodium bicarbonate, brine, dried over magnesium sulfate, filtered and concentrated
- 30 to afford a clear oil. This was recrystallized from diethyl ether to afford 1.27 g of carbamic acid, [2R-hydroxy-3-[[[4-methoxyphenyl)sulfonyl](2-methylpropyl)

amino]-1S-(phenylmethyl)propyl]-, phenylmethyl ester, mp 97-101°C, mass spectrum m/e=541 (M+H).

Part C:

5 A solution of 930mg (3.20 mmol) of the product of part B in 30 mL of methanol was hydrogenated in the presence of 70 mg of a 10% palladium on carbon catalyst under 40 psig for 17 hours, the catalyst was removed by filtration, and the solution concentrated to afford 704
10 mg of [2R-hydroxy-3-[[4-methoxyphenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propylamine, mass spectrum m/e = 407 (M+H), which was used directly in the next step without purification.

15 Part D:

To a solution of 2.5g (22.9 mmol) of 3-pyridylcarbinol in 100 mL of anhydrous acetonitrile was added 8.8 g (34.4 mmol) of N,N'-disuccinimidyl carbonate and 5.55 mL (68.7 mmol) of pyridine. The solution was
20 stirred for 1 hour and then concentrated in vacuo. The residue was dissolved in ethyl acetate, then washed with saturated sodium bicarbonate, brine, dried over magnesium sulfate, filtered and concentrated to afford 5.3 g of N-Hydroxysuccinimide-3-pyridylmethyl carbonate, mass
25 spectrum m/e = 251 (M+H), which was used directly in the next step without purification.

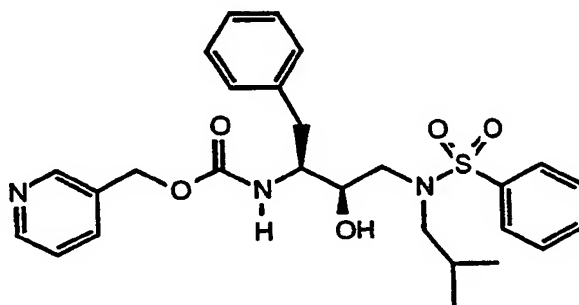
Part E:

To a solution of the amine from part C (2.87g, 7.0 mmol) and 1.38 mL of triethylamine in 24 mL of
30 anhydrous methylene chloride was added a solution of 1.65g (6.6 mmol) of N-hydroxysuccinimide-3-pyridyl carbonate from part D in 24 mL of methylene chloride. The solution was stirred for 1 hour, 100 mL of methylene chloride
35 added, then washed with saturated sodium bicarbonate, brine, dried over sodium sulfate, filtered and concentrated to afford 3.69 g of crude product. Chromatography on silica gel using 2% methanol/methylene

chloride to afford 3.27 g of carbamic acid, [2R-hydroxy-3-[[[(4-methoxyphenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-, 3-pyridylmethyl ester, mass spectrum $m/e = 548$ (M+Li).

5

Example 13C



10 Preparation of Carbamic acid, [2R-hydroxy-3-[(phenylsulfonyl)(2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-, 3-pyridylmethyl ester

Part A:

15 A solution of N-benzyloxycarbonyl-3S-amino-1,2-S-epoxy-4-phenylbutane (50g, 0.168 mol) and isobutylamine (246g, 3.24 mol) in 650 mL of isopropyl alcohol was refluxed for 1.25 hours. The solution was cooled to room temperature, concentrated in vacuo and then poured into
20 1L of stirring hexane whereupon the product crystallized from solution, was collected and air dried to give 57.6 g of N-[3S-benzyloxycarbonylamino-2R-hydroxy-4-phenyl]-N-isobutylamine, mp 108-109.5 C, mass spectrum $m/e=371$ (M+H).

25

Part B:

The amine from part A (0.94g, 2.5 mmol) and triethylamine (288 mg, 2.85 mmol) in 20 mL of methylene chloride was treated with 461 mg (2.61 mmol) of
30 benzenesulfonyl chloride. The solution was stirred at room temperature for 16 hours, concentrated, dissolved in ethyl acetate, then washed with 1N potassium hydrogen

sulfate, saturated sodium bicarbonate, brine, dried over magnesium sulfate, filtered and concentrated to afford a clear oil. This was recrystallized from diethyl ether and hexane to afford 0.73 g of carbamic acid, [2R-hydroxy-3-[(phenylsulfonyl)(2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-, phenylmethyl ester, mp 95-99 C, mass spectrum m/e=511 (M+H).

Part C:

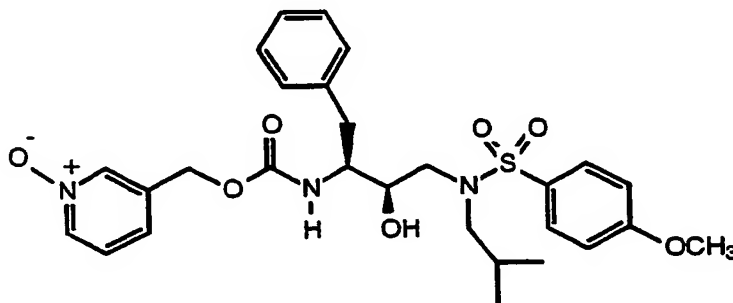
10 A solution of 500mg of carbamic acid, [2R-hydroxy-3-[(phenylsulfonyl)(2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-, phenylmethyl ester in 20 mL of methanol was hydrogenated in the presence of 250 mg of a 10% palladium on carbon catalyst under 40 psig for 3
15 hours, the catalyst was removed by filtration, and the solution concentrated to afford 352 mg of [2R-hydroxy-3-[(phenylsulfonyl)(2-methylpropyl)amino]-1S-(phenylmethyl)propylamine, mass spectrum m/e = 377 (M+H), which was used directly in the next step without
20 purification.

Part D:

To a solution of 1.24 mmol of 5-norbornene-2,3-dicarboximido carbonochloridate (Henklein, P., et. al.,
25 Synthesis 1987, 166-167) in 1 mL of anhydrous methylene chloride, was added a solution of 43 μ L (2.44 mmol) of 3-pyridylcarbinol and 129 μ L (1.6 mmol) of pyridine in 1 mL of methylene chloride at 0°C under a nitrogen atmosphere. After 4 hours at room temperature, 150 mg (0.4 mmol) of
30 [2R-hydroxy-3-[(phenylsulfonyl)(2-methylpropyl)amino]-1S-(phenylmethyl)propylamine from Part C above was added and 100 μ L of pyridine. After stirring for 15 hours at room temperature, ethyl acetate was added, then washed with 1N hydrochloric acid, saturated sodium bicarbonate, brine,
35 dried over magnesium sulfate, filtered and concentrated to afford 175 mg of crude product. Chromatography over silica gel using 1% methanol/methylene chloride to afford 69 mg of pure carbamic acid, [2R-hydroxy-3-

[(phenylsulfonyl)(2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-, 3-pyridylmethyl ester, mass spectrum m/e = 512.2267 (M+H); calcd for C₂₇H₃₃N₃O₅S, 512.2219.

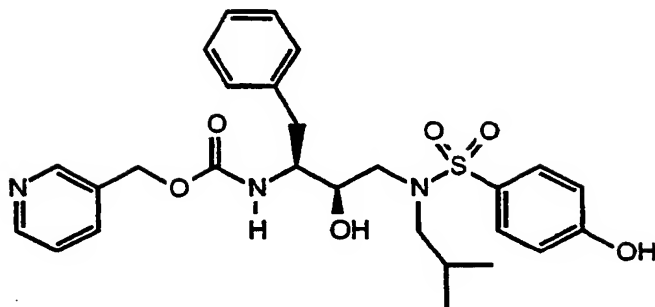
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Example 13D

Preparation of Carbamic acid, [2R-hydroxy-3-[[[4-methoxyphenyl)sulfonyl]](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-, 3-pyridylmethyl ester, N-oxide

To a solution of 211mg (0.39 mmol) of carbamic acid, [2R-hydroxy-3-[[[4-methoxyphenyl)sulfonyl]](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-, 3-pyridylmethyl ester in 5mL of methylene chloride at 0°C was added 500 mg of 50% 3-chloroperbenzoic acid. After stirring at room temperature for 1 hour, ethyl acetate was added, the solution washed with saturated sodium bicarbonate, 0.2N ammonium hydroxide solution and brine, dried over magnesium sulfate, filtered and concentrated to afford 200 mg of crude product. This was chromatographed on C18 reverse phase material using 20-40% acetonitrile/water, then 100% acetonitrile to afford 90mg of the desired product, which was then recrystallized from ethyl acetate/isooctane to yield 34mg of pure carbamic acid, [2R-hydroxy-3-[[[4-methoxyphenyl)sulfonyl]](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-, 3-pyridylmethyl ester, N-oxide; mass spectrum m/e=564 (M+Li).

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Example 13E

5 Preparation of Carbamic acid, [2R-hydroxy-3-[[[(4-hydroxyphenyl)sulfonyl]](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-, 3-pyridylmethyl ester

Part A:

10 A solution of 0.98 g (1.85 mmol) of carbamic acid, [2R-hydroxy-3-[[[(4-fluorophenyl)sulfonyl]](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-phenylmethyl ester in 3.8 mL of anhydrous DMF was added to 22mg (7.4 mmol) of 80% sodium hydride in 2 mL of DMF. To this
 15 mixture was added 0.40g (3.7 mmol) of benzyl alcohol. After 2 hours, the solution was cooled to 0 C, water, added, and then ethyl acetate. The organic layer was washed with 5% citric acid, saturated sodium bicarbonate and brine, dried over magnesium sulfate, filtered and
 20 concentrated to afford 0.90g of crude material. This was chromatographed on basic alumina using 3% methanol/methylene chloride to afford 0.70g of 2R-hydroxy-3-[(2-methylpropyl)(4-hydroxyphenyl)sulfonyl]amino-1S-(phenylmethyl)propylamine, cyclic carbamate;
 25 mass spectrum m/e=509 (M+H).

Part B:

To a solution of 0.65g (1.28 mmol) of the cyclic carbamate from part A in 15 mL of ethanol, was added 2.6 mL (6.4 mmol) of 2.5N sodium hydroxide solution. After 1 hour at reflux, 4 mL of water was added and the solution refluxed for an additional eight hours. The volatiles were removed, ethyl acetate added, and washed with water, brine, dried over magnesium sulfate, filtered and concentrated to afford 550 mg of crude 2R-hydroxy-3-[(2-methylpropyl)(4-hydroxyphenyl)sulfonyl]amino-1S-(phenylmethyl)propylamine.

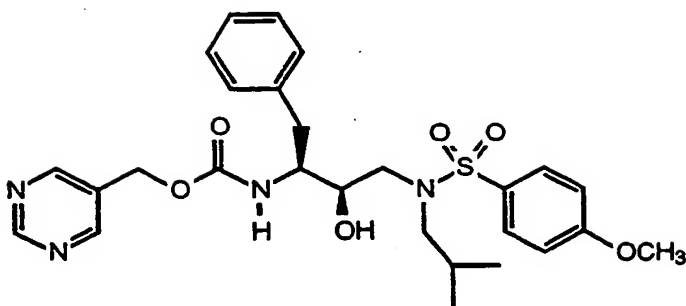
Part C:

A solution of crude 2R-hydroxy-3-[(2-methylpropyl)(4-benzyloxyphenyl)sulfonyl]amino-1S-(phenylmethyl)propylamine in 10 mL of ethanol was hydrogenated in the presence of 500 mg of a 10% palladium on carbon catalyst under 50 psig of hydrogen for 2 hours. The catalyst was removed by filtration and the solvent removed in vacuo to afford 330 mg of 2R-hydroxy-3-[(2-methylpropyl)(4-hydroxyphenyl)sulfonyl]amino-1S-(phenylmethyl)propylamine, mass spectrum $m/e = 393$ (M+H).

Part D:

To a solution of 320 mg (0.82 mmol) of the amine from part C in 6 mL of DMF, was added 192 mg (0.76 mmol) of N-hydroxysuccinimide-3-pyridylmethyl carbonate. After 15 hours at room temperature, the DMF was removed in vacuo, ethyl acetate added, washed with water, brine, dried with magnesium sulfate, filtered and concentrated to afford 390 mg of crude material. Chromatography on silica gel using 50-80% ethyl acetate/hexane afforded 180 mg of carbamic acid, [2R-hydroxy-3-[(4-hydroxyphenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-, 3-pyridylmethyl ester, mass spectrum $m/e = 528$ (M+H).

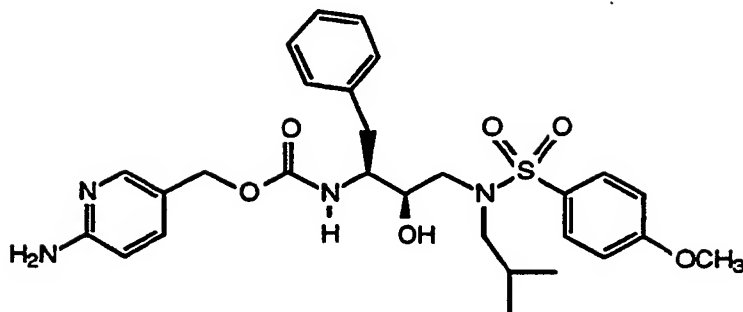
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Example 13F

- 5 Preparation of Carbamic acid, [2R-hydroxy-3-[[[(4-methoxyphenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-, 5-pyrimidylmethyl ester

To a solution of 9.5mg (0.09mmol) of 5-pyrimidylcarbinol in 1mL of anhydrous acetonitrile at room temperature, was added 24mg (0.09mmol) of N,N'-disuccinimidyl carbonate and 19.1 μ L (0.24mmol) of pyridine. After stirring for 5 hours, 32 mg (0.08mmol) of 2R-hydroxy-3-[(2-methylpropyl)(4-methoxyphenyl)sulfonyl]amino-1S-(phenylmethyl)propylamine was added and the solution stirred for 48 hours. After concentration in vacuo, methylene chloride was added, then washed with a 1:1 mixture of saturated sodium bicarbonate and brine, dried over magnesium sulfate, filtered and concentrated to give 27 mg of crude product. Chromatography on silica gel using 2% methanol/methylene chloride afforded 22 mg of the desired product, mass spectrum m/e=543 (M+H).

112

Example 13G

- 5 Preparation of Carbamic acid, [2R-hydroxy-3-[[[4-methoxyphenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-, 3-(6-aminopyridyl)methyl ester.

Part A: Preparation of Ethyl 6-Aminonicotinate

10

To a suspension of 1.3g (9.4 mmol) 6-aminonicotinic acid in 100 mL of ethanol, was bubbled in dry hydrochloric acid at 0°C, then the solution was refluxed until all the solids dissolved. The solvents were removed under reduced

15 pressure, the residue dissolved in ethyl acetate, washed with saturated sodium bicarbonate, brine and concentrated to afford 1.37g of a white solid, m/e=166(M+H).

Part B: Preparation of Ethyl 6-(tert-Butyloxycarbonylamino)nicotinate

20

A mixture of 848 mg(5.1 mmol) of ethyl 6-aminonicotinate from part A, 1.11g(5.1 mmol) of di-tert-butylpyrocarbonate and 0.71 mL (5.1 mmol) of triethylamine in 10mL of anhydrous

25 toluene was refluxed for 15 hours. The solution was cooled, ethyl acetate added, washed with saturated sodium bicarbonate, brine, dried over anhydrous magnesium sulfate, filtered and concentrated to afford 1.28g of the desired ethyl 6-(tert-butyloxycarbonylamino)nicotinate,

30 m/e=267(M+H), which was used directly in the next step.

113.

Part C: Preparation of 6-(tert-Butyloxycarbonylamino)-3-pyridylmethanol

To 4.6 mL (4.6 mmol) of a 1M solution of lithium aluminum hydride in diethyl ether at -40°C under a nitrogen atmosphere, was added a slution of 618mg (2.3 mmol) of ethyl 6-(tert-butyloxycarbonylamino)nicotinate from part B in 40 mL of anhydrous tetrahydrofuran. After the addition, this was warmed to room temperature, stirred for 3 hours, cooled to 0°C, and 145 µL of water, 145µL of 20% sodium hydroxide solution and 290µL of water were successively added. To the resulting mixture was added 50mL of tetrahydrofuran and stirring continued for 30 minutes. Anhydrous magnesium sulfate was added, the solids removed via filtration and the filtrate concentrated under reduced pressure to afford 460 mg of the desired product, m/e=224(M+), which was used directly in the next step.

Part D: Preparation of Carbamic acid, [2R-hydroxy-3-[(4-methoxyphenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-, 3-[(6-tert-butyloxycarbonylamino)pyridyl]methyl ester

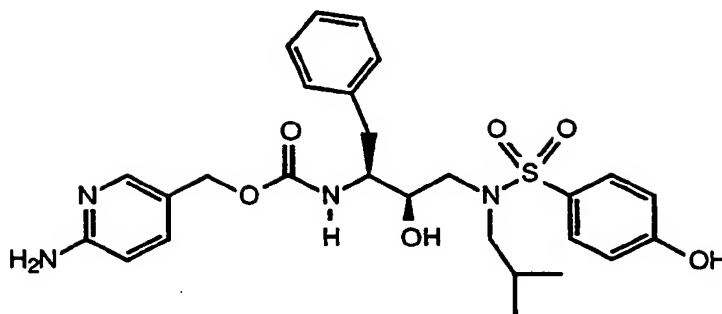
To a solution of 336 mg (1.5mmol) of 6-(tert-butyloxycarbonylamino)-3-pyridylmethanol from part C in 14 mL of anhydrous acetonitrile at room temperature under a nitrogen atmosphere, was added 384 mg(1.5mmol) of N,N'-disuccinimidyl carbonate and 364 µL (4.5mmol) of anhydrous pyridine. After 4 hours, 406mg (1mmol) of 2R-hydroxy-3-[(2-methylpropyl)(4-methoxyphenyl)sulfonyl]amino-1S-(phenylmethyl)propylamine was added and stirring continued for 19 hours. The solvent was removed under reduced pressure, ethyl acetate added, washed with saturated sodium bicarbonate, brine, dried over magnesium sulfate, filtered and concentrated to afford 702 mg of crude product. Chromatography on silica gel using 1% methanol/methylene chloride as eluent afforded 170 mg of the desired carbamic acid, [2R-hydroxy-3-[(4-methoxyphenyl)sulfonyl](2-

methylpropyl)amino]-1S-(phenylmethyl)propyl]-, 3-[(6-tert-butylloxycarbonylamino)pyridyl)methyl ester, m/e=663 (M+Li).

Part E: Preparation of Carbamic acid, [2R-hydroxy-3-[[[4-methoxyphenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-, 3-(6-aminopyridyl)methyl ester

To 5mL of 4N hydrochloric acid in dioxane at room temperature, was added 150mg (0.23mmol) of carbamic acid, [2R-hydroxy-3-[[[4-methoxyphenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-, 3-[(6-tert-butylloxycarbonylamino)pyridyl)methyl ester from part D. After stirring at room temperature for 28 hours, the solvent was removed under reduced pressure, the resulting solids triturated with diethyl ether, then dissolved in ethyl acetate and saturated sodium bicarbonate slution, separated, the organic layer washed with brine, dried with magnesium sulfate, filtered and concentrated. The residue was chromatographed on silica gel using 2.5% methanol/methylene chloride to yield 59mg of the desired carbamic acid, [2R-hydroxy-3-[[[4-methoxyphenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-, 3-(6-aminopyridyl)methyl ester, m/e=557 (M+H).

115

Example 13H

- 5 Preparation of Carbamic acid, [2R-hydroxy-3-[[[4-hydroxyphenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-, 3-(6-aminopyridyl)methyl ester.

Part A: Preparation of Carbamic acid, [2R-hydroxy-3-[[[4-methoxyphenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-, 3-[(6-tert-

10 butyloxycarbonylamino)pyridyl)methyl ester

To a solution of 505 mg (2.25mmol) of 6-(tert-

15 butyloxycarbonylamino)-3-pyridylmethanol from in 20 mL of anhydrous acetonitrile at room temperature under a nitrogen atmosphere, was added 576 mg (2.25mmol) of N,N'-disuccinimidyl carbonate and 546 μ L (6.75mmol) of anhydrous pyridine. After 1 hour, 837mg (1.87mmol) of 2R-hydroxy-3-

20 [(2-methylpropyl)(4-hydroxyphenyl)sulfonyl]amino-1S-(phenylmethyl)propylamine was added and stirring continued for 3 hours. The solvent was removed under reduced pressure, ethyl acetate added, washed with saturated sodium bicarbonate, brine, dried over magnesium sulfate, filtered

25 and concentrated to afford 1.37g of crude product. Chromatography on silica gel using 1% methanol/methylene chloride as eluent afforded 830 mg of material which was identified as a mixture of the desired carbamic acid, [2R-hydroxy-3-[[[4-hydroxyphenyl)sulfonyl](2-methylpropyl)

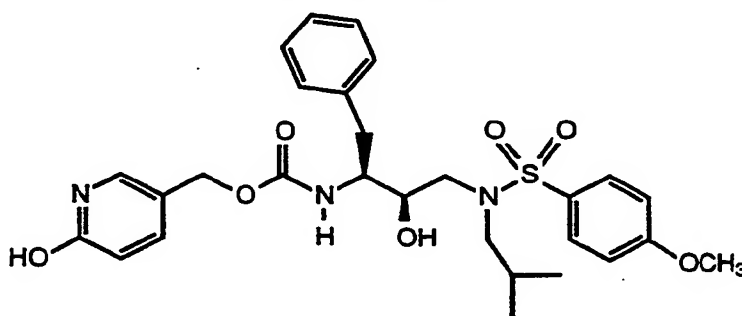
30 amino]-1S-(phenylmethyl)propyl]-, 3-[(6-tert-butyloxycarbonylamino)pyridyl)methyl ester and the cyclic carbamate derived from the 2R-hydroxy-3-[(2-methylpropyl)(4-

hydroxyphenyl)sulfonyl]amino-1S-(phenylmethyl)propylamine. The mixture was very difficult to separate, so was used as is in the next step.

- 5 Part B: Preparation of Carbamic acid, [2R-hydroxy-3-[[4-hydroxyphenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-, 3-(6-aminopyridyl)methyl ester

To 830mg of the mixture from part A, was added 50mL of a 1:1
 10 mixture of trifluoroacetic acid and methylene chloride. After 2.5 hours at room temperature, the solvent was removed under reduced pressure, ethyl acetate added, washed with saturated sodium bicarbonate, dried over magnesium sulfate, filtered and concentrated to afford 720 mg of crude
 15 material. This was chromatographed on silica gel using 5% methanol/ethyl acetate as eluent to yield 220mg of product, which was recrystallized from methylene chloride/diethyl ether to afford 108mg of the desired carbamic acid, [2R-hydroxy-3-[[4-hydroxyphenyl)sulfonyl](2-methylpropyl)
 20 amino]-1S-(phenylmethyl)propyl]-, 3-(6-aminopyridyl)methyl ester, m/e=549 (M+Li).

Example 13I



25.

Preparation of Carbamic acid, [2R-hydroxy-3-[[4-methoxyphenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-, 3-(6-hydroxypyridyl)methyl ester.

30

Part A: Preparation of tert-Butyldimethylsilyl 6-(tert-butyldimethylsiloxy)nicotinate

To a solution of 5.0g (35.9mmol) of 6-hydroxynicotinic acid in 200mL of anhydrous N,N-dimethylformamide at room temperature, was added 8.56g (125mmol) of imidazole and then
5 13.5g (89mmol) of tert-butyldimethylsilyl chloride. After 20 hours, the solvent was removed under reduced pressure, ethyl acetate added, washed with water, 5% citric acid, saturated sodium bicarbonate, brine, dried over anhydrous magnesium sulfate, filtered and concentrated to afford 10.5
10 g of crude material, m/e=368 (M+H).

Part B: Preparation of 3-(6-tert-butyldimethylsiloxy)pyridylcarbinol

15 To 11mL of 1M solution of lithium aluminum hydride in diethyl ether at -35°C under a nitrogen atmosphere, was added a solution of 2.0g (5.46mmol) of product from part A in 20mL of anhydrous diethyl ether. After 30 minutes, the reaction was warmed to 0°C and stirred for 40 minutes. The
20 solution was then quenched by the careful addition of 0.42mL of water, 0.42mL of 20% sodium hydroxide solution, and 0.84mL of ether. Ethyl acetate was added, the precipitate filtered and the organic phase concentrated to yield 0.93 g of crude 3-(6-tert-butyldimethylsiloxy)pyridylcarbinol,
25 which was used directly in the next step.

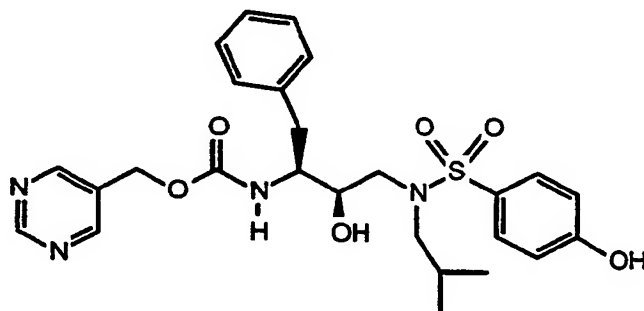
Part C: Preparation of Carbamic acid, [2R-hydroxy-3-[[[4-methoxyphenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-, 3-(6-hydroxypyridyl)methyl ester

30

To a solution of 860mg (3.6mmol) of material from part B in 15mL of anhydrous acetonitrile, was added 919mg (3.6mmol) of N,N'-disuccinimidyl carbonate and 0.87mL of pyridine. After 1 hour, 1.42g (3.5mmol) of 2R-hydroxy-3-[(2-methylpropyl)(4-methoxyphenyl)sulfonyl]amino-1S-(phenylmethyl)propylamine
35 was added. After 14 hours at room temperature, the solvent was removed under reduced pressure, the residue dissolved in ethyl acetate, washed with 5% citric acid, saturated sodium

bicarbonate, brine, dried over magnesium sulfate, filtered and concentrated to afford 2.1 g of crude material. This was directly deprotected by dissolving in 40mL of 80% acetic acid/water and stirring for 2 hours. The solvents were removed under reduced pressure, the residue dissolved in ethyl acetate, washed with saturated sodium bicarbonate, brine, dried over magnesium sulfate, filtered and concentrated to afford 1.7g of crude product. This was chromatographed on silica gel using 50-100% ethyl acetate/hexane to provide a fraction of 0.19g of fairly pure material, which was further purified by reverse phase chromatography using 15-40% acetonitrile/water (0.05% trifluoroacetic acid) to provide 120mg of the desired carbamic acid, [2R-hydroxy-3-[[[(4-methoxyphenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-, 3-(6-hydroxypyridyl)methyl ester, m/e=558 (M+H).

Example 13J



Preparation of Carbamic acid, [2R-hydroxy-3-[[[(4-hydroxyphenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl], 5-pyrimidylmethyl ester.

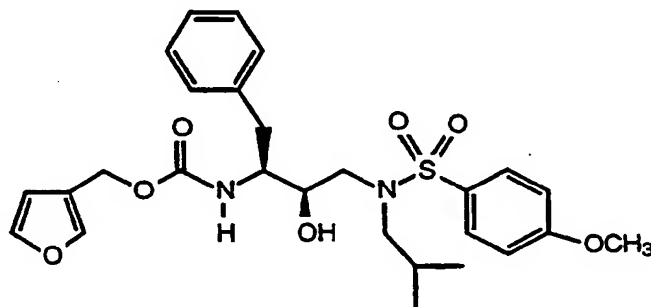
To a solution of 237mg (2.15mmol) of 5-pyrimidinylcarbinol in 24mL of anhydrous acetonitrile, was added 602mg (2.35mmol) of N,N'-disuccinimidyl carbonate and then 0.47mL of pyridine. After stirring for 4.5 hours, 766mg (1.96mmol) of 2R-hydroxy-3-[(2-methylpropyl)(4-hydroxyphenyl)sulfonyl]amino-1S-(phenylmethyl)propylamine was added. After stirring for 19 hours, the solvent was

removed under reduced pressure, ethyl acetate added, washed with 5% citric acid, saturated sodium bicarbonate, brine, dried over anhydrous magnesium sulfate, filtered and concentrated to afford 1.0 g of crude material.

- 5 Chromatography on silica gel using 50-100% ethyl acetate/hexane as eluent afforded 450 mg of the desired carbamic acid, [2R-hydroxy-3-[[(4-hydroxyphenyl) sulfonyl] (2-methylpropyl) amino]-1S-(phenylmethyl)propyl]-, 5-pyrimidylmethyl ester, m/e=529 (M+H).

10

Example 13K



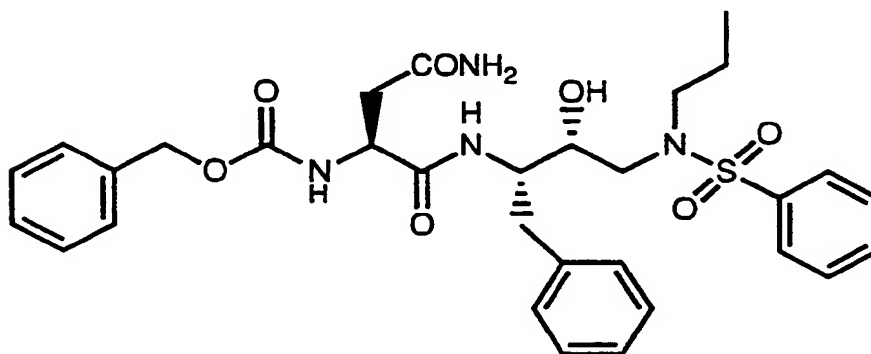
- 15 Preparation of Carbamic acid, [2R-hydroxy-3-[[(4-methoxyphenyl) sulfonyl] (2-methylpropyl) amino]-1S-(phenylmethyl)propyl]-, 3-furanylmethyl ester

To a solution of 98mg (1 mmol) of 3-(hydroxymethyl)furan
20 in 3 mL of anhydrous acetonitrile, was added 242 μ L of pyridine and then 256 mg of N,N'-disuccinimidyl carbonate at room temperature under nitrogen. After 45 minutes, 406 mg (1 mmol) of 2R-hydroxy-3-[(2-methylpropyl) (4-methoxyphenyl) sulfonyl] amino-1S-(phenylmethyl)propylamine
25 was added. After stirring at room temperature for 16 hours, ethyl acetate was added, washed with 5% citric acid, saturated sodium bicarbonate and brine, dried over magnesium sulfate, filtered and concentrated to afford 565 mg of crude product. This was chromatographed on
30 silica gel using 50% ethyl acetate/hexane as eluent to afford 305mg of a white foam, which was recrystallized from diethyl ether/hexane to yield 245 mg of pure

120

carbamic acid, [2R-hydroxy-3-[[(4-methoxyphenyl)sulfonyl]
(2-methylpropyl)amino]-1S-(phenylmethyl)propyl-, 3-
furanylmethyl ester, m/e = 537(M+Li).

5

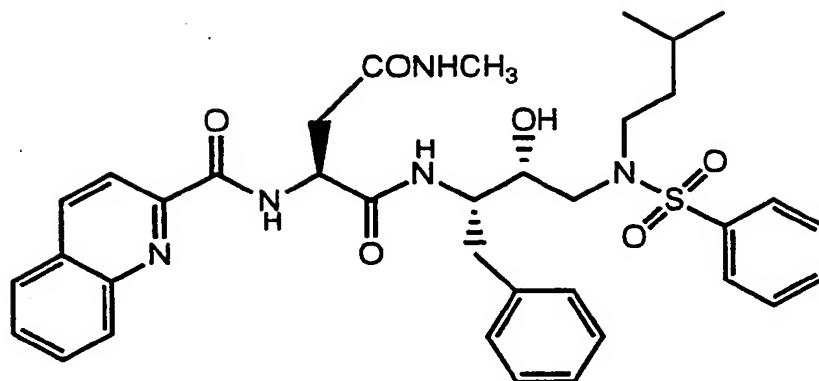
Example 14

10 Preparation of phenylmethyl[3-amino-1S-[[2R-hydroxy-3-
[(3-propyl)(phenylsulfonyl)amino]-1S-
(phenylmethyl)amino]carbonyl]-3-oxopropyl]carbamate

Phenylmethyl [2R-hydroxy-3-[(3-propyl)(phenylsulfonyl)
15 amino]-1S-(phenylmethyl)propyl]carbamate (200 mg, 0.40
mmol) was deprotected by hydrogenation over 10% palladium
on carbon and the resulting free amine was coupled with
N-CBZ-L-asparagine (157 mg, 0.42 mmol) in the presence of
N-hydroxybenzotriazole (114 mg, 0.84 mmol) and EDC
20 (130 mg, 0.67 mmol) to give phenylmethyl[3-amino-1S-[[2R-
hydroxy-3-[(3-propyl)(phenylsulfonyl)amino]-1S-
(phenylmethyl)amino]carbonyl]-3-oxopropyl]carbamate as a
solid. Anal. Calcd for C₃₁H₃₈N₄O₇S.0.2H₂O: C, 60.61;
H, 6.30; N, 9.12. Found: C, 60.27; H, 6.16; N, 8.93.

25

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Example 15A

5 Preparation of N¹-[2R-hydroxy-3-[(3-methylbutyl)(phenylsulfonyl)amino]-N⁴-methyl-1S-(phenylmethyl)propyl]-2S-[(2-quinolinylcarbonyl)amino]butanediamide

Part A:

10 N²-[(1,1-dimethylethoxy)carbonyl]-N-methyl-L-asparagine was prepared from Boc-L-aspartic acid alpha-benzyl ester (1.0 g, 3.09mmol), methylamine.HCl (209 mg, 3.09mmol), EDC (711 mg, 3.7 mmol), 1-hydroxybenzotriazole (627 mg, 4.63 mmol), and N-methylmorpholine (0.7 mL, 6.3
15 mmol), in DMF (20mL). After stirring overnight at room temperature, the reaction mixture was diluted with ethyl acetate, washed with water, saturated sodium bicarbonate, 5% citric acid, brine, dried over magnesium sulfate and concentrated to an oil. The oil was taken up in 20 mL
20 dry ethanol, and hydrogenated in the presence of 10% w/w of 10% Pd on C at atmospheric pressure and room temperature overnight. The mixture was filtered through Celite and concentrated to a white solid foam, 670 mg.

25 Part B:

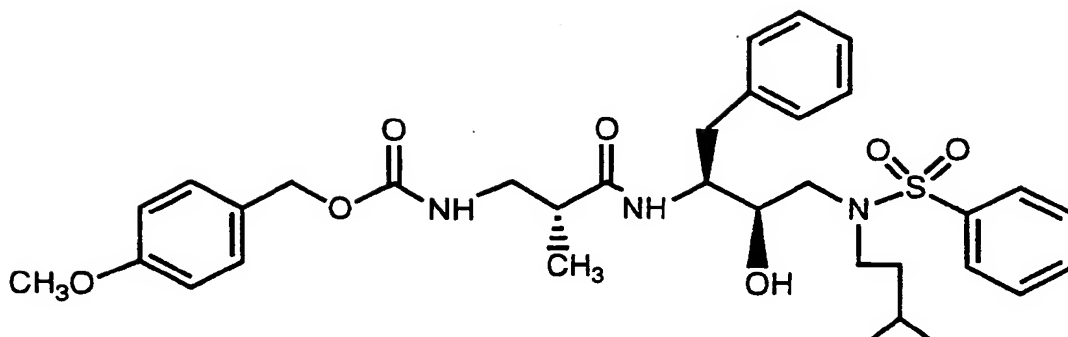
A solution of phenylmethyl [2R-hydroxy-3-[(3-methylbutyl)(phenylsulfonyl)amino]-1S-(phenylmethyl)-propyl]carbamate (310 mg, 0.59 mmol) in methanol (10mL) was hydrogenated over 10% palladium on carbon for 3 h.,
30 filtered through diatomaceous earth and concentrated to

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give the product as an oil (214 mg). This free amine (208 mg, 0.53 mmol) was coupled with N²-[(1,1-dimethylethoxy)-carbonyl]-N-methyl-L-asparagine (137 mg, 0.56 mmol) in the presence of N-hydroxybenzotriazole (102 mg, 0.76 mmol) and EDC (130 mg, 0.67 mmol) to yield 290 mg of N¹[2R-hydroxy-3-[(3-methylbutyl)(phenylsulfonyl)-amino]-N⁴-methyl-1S-(phenylmethyl)propyl]-2S-[(1,1-dimethylethoxy-carbonyl)amino]butane diamide.

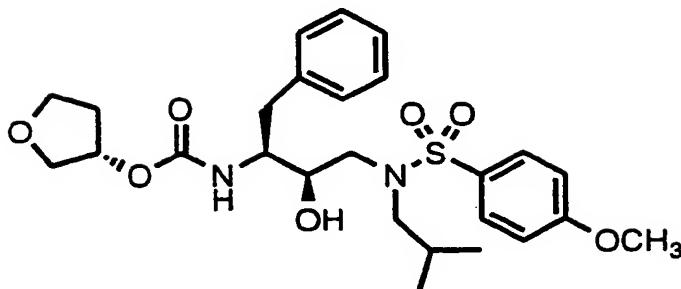
10 Part C:

N¹[2R-hydroxy-3-[(3-methylbutyl)(phenylsulfonyl)amino]-N⁴-methyl-1S-(phenylmethyl)propyl]-2S-[(1,1-dimethylethoxycarbonyl)-amino]butane diamide (270 mg, 0.43 mmol) was stirred in 4N HCl in dioxane (5 mL) at room temperature for 0.5 hr. Solvent and excess reagent were evaporated to dryness. The product was dried in vacuo. This material (125 mg, 0.225 mmol) was then reacted with 2-quinolinecarboxylic acid N-hydroxysuccinimide ester (61 mg, 0.225 mmol), N-methylmorpholine (50 uL, 0.45 mmol) in methylene chloride (2 mL) for 3 h. The product N¹[2R-hydroxy-3-[(3-methylbutyl)(phenylsulfonyl)amino]-N⁴-methyl-1S-(phenylmethyl)propyl]-2S-[(2-quinolinylcarbonyl)-amino]butanediamide was purified by silica gel chromatography. Anal. Calcd for C₃₆H₄₃N₅O₆S.0.2H₂O: C, 63.83; H, 6.45; N, 10.34. Found: C, 63.64; H, 6.40; N, 10.34.

Example 15B

- 5 Preparation of Carbamic acid, [3-[[2-hydroxy-3-[(3-methylbutyl)(phenylsulfonyl)amino]-1-(phenylmethyl)propyl]amino]-2-methyl-3-oxopropyl]-, (4-methoxyphenyl)methyl ester, [1S-[1R*(S*),2S*]]-
- 10 Carbamic acid, [2R-hydroxy-3-[(3-methylbutyl)(phenylsulphonyl)amino]-1S-(phenylmethyl)propyl]-, phenylmethyl ester (4.10g, 7.8 mmol) was hydrogenated in a solution of methanol and ethanol using catalytic Pd/C 10% at 50 psig hydrogen for 3 hours. The catalyst was
- 15 filtered and the solvents removed in vacuo to yield 3.0 grams of free amine. In a separate flask, 2.09g, (7.8 mmol), of N-Moz-AMBA was added to 10 mL of dimethylformamide and 1.58g, (1.5 equiv.), of N-hydroxybenzotriazole and the solution was cooled to 5°C.
- 20 To this solution was added 1.49g, (7.8 mmol), of EDC and the solution stirred for 30 min. To this was added the free amine in 10 mL of dimethylformamide, and the reaction was stirred for 20 hours. The solvent was removed by evaporation and the crude material was
- 25 partitioned between ethyl acetate and saturated aqueous sodium bicarbonate. The ethyl acetate layer was washed with 5% potassium hydrogen sulfate and brine, dried over magnesium sulfate, filtered and concentrated to yield 2.58 grams (52%) of pure product after recrystallization
- 30 from ethyl acetate, ether, and hexanes.

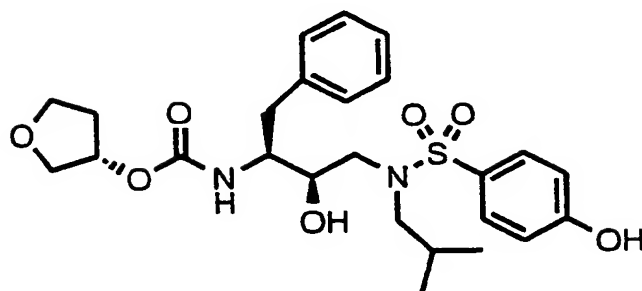
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Example 16A

5 Preparation of Carbamic acid, [2R-hydroxy-3-[(4-
methoxyphenylsulfonyl)(2-methylpropyl)amino]-1S-
(phenylmethyl)propyl-, tetrahydrofuran-3S-yl ester,

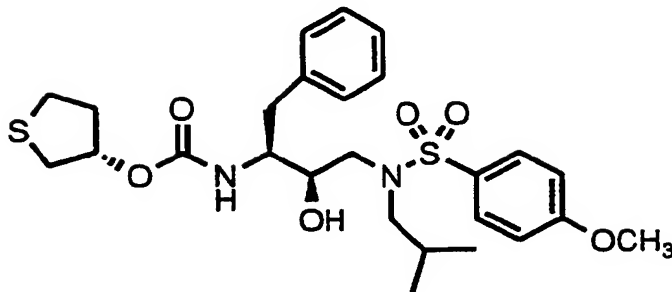
To a solution of 406 mg (1.0 mmol) of [2R-hydroxy-3-[[4-
 10 methoxyphenyl)sulfonyl](2-methylpropyl)amino]-1S-
 (phenylmethyl)propylamine in 5.0 mL of dichloromethane
 containing 150 mg (1.5mmol) of triethylamine was added
 280mg (1.22 mmol) of N-succinimidyl-3S-tetrahydrofuranyl
 carbonate and the reaction mixture was stirred for 2
 15 hours, an additional 136 mg (0.3mmol) of amine was added
 to the mixture and the solution stirred another 2 hours.
 The contents were diluted with 50 mL of ethyl acetate and
 washed with 5% aqueous citric acid, saturated sodium
 bicarbonate, and brine, then dried over magnesium
 20 sulfate, filtered and concentrated to yield 330 mg of
 crude product. Purification by silica gel chromatography
 using an eluant of 1:1 to 2:1 ethyl acetate/hexanes
 gradient provided Carbamic acid, [2R-hydroxy-3-[(4-
 methoxyphenylsulfonyl)(2-methylpropyl)amino]-1S-
 25 (phenylmethyl)propyl-, tetrahydrofuran-3S-yl ester as a
 white solid. m/z = 521 (M+H) calc. 521.2311 obs.
 521.2311.

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Example 16B

5 Preparation of Carbamic acid, [2R-hydroxy-3-[(4-
hydroxyphenylsulfonyl)(2-methylpropyl)amino]-1S-
(phenylmethyl)propyl-, tetrahydrofuran-3S-yl ester.

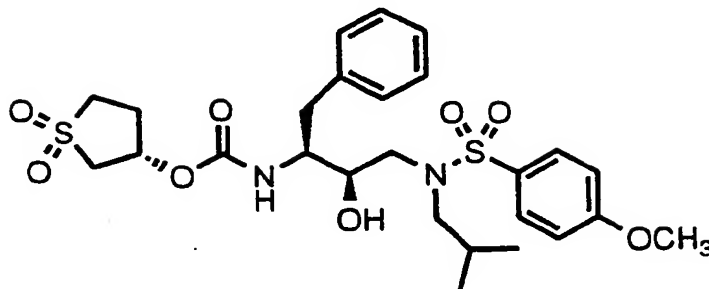
To a solution of 435 mg (1.0 mmol) of [2R-hydroxy-3-[(4-
10 hydroxyphenyl)sulfonyl](2-methylpropyl)amino]-1S-
(phenylmethyl)propylamine in 3.0 mL of dimethylformamide
was added 225mg (0.98 mmol) of N-succinimidyl-3S-
tetrahydrofuran-3S-yl carbonate and the solution was stirred
overnight. The mixture was diluted with 50 mL of ethyl
15 acetate and washed with 5% aqueous citric acid,
saturated sodium bicarbonate, and brine, dried over
magnesium sulfate, filtered and concentrated to yield 515
mg of crude product. Purification by silica gel
chromatography using and eluant of 1:1 ethyl acetate:
20 hexanes provided 315 mg of Carbamic acid, [2R-hydroxy-3-
[(4-hydroxyphenylsulfonyl)(2-methylpropyl)amino]-1S-
(phenylmethyl)propyl-, tetrahydrofuran-3S-yl ester, as a
white solid. HRMS calc. 507.2165, obs. 507.2155.

Example 16C

5 Preparation of Carbamic acid, [2R-hydroxy-3-[(4-methoxyphenylsulfonyl)(2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-, tetrahydrothiophen-3S-yl ester,

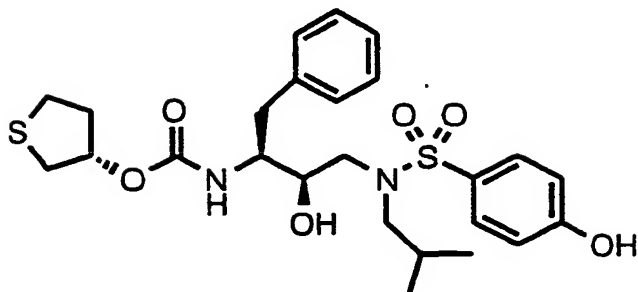
To a solution of 215 mg (2.0mmol) of 3S-hydroxythiophene,
10 415 μ L of anhydrous pyridine, and 2 mL of dry acetonitrile
was added 512 mg (2.0 mmol) of N,N'-Dimethylsuccinimidyl
carbonate and this suspension was stirred for 45 minutes.
To this clear solution was added a solution of 700 mg
(1.7 mmol) of [2R-hydroxy- 3-[[(4-methoxyphenyl)
15 sulfonyl] (2-methylpropyl)amino]-1S-(phenylmethyl)
propylamine in 2.0 mL of acetonitrile and stirred for 12
hours. The contents were concentrated, and the residue
was partitioned between ethyl acetate and 5% aqueous
potassium hydrogen sulfate. The organic layer was washed
20 with saturated sodium bicarbonate and then brine, dried
over sodium sulfate, filtered and concentrated to yield
780 mg of crude material. Purification by silica gel
chromatography using an eluant of 10:10:1 ethyl acetate:
hexane:methanol provided 520 mg of Carbamic acid, [2R-
25 hydroxy-3-[(4-methoxyphenylsulfonyl)(2-methylpropyl)
amino]-1S-(phenylmethyl)propyl]-, tetrahydrothiophen-3S-
yl-ester, as a crystalline white solid. m.p.= 162-3°C,
m/z= 553 (M+H).

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Example 16D

- 5 Preparation of Carbamic acid, [2R-hydroxy-3-[(4-methoxyphenylsulfonyl)(2-methylpropyl)amino]-1S-(phenylmethyl)propyl-, 1,1-dioxotetrahydrothiophen-3S-yl ester
- 10 To a solution of 270 mg (0.5 mmol) of Carbamic acid, [2R-hydroxy-3-[(4-methoxyphenylsulfonyl)(2-methylpropyl)amino]-1S-(phenylmethyl)propyl-, tetrahydrothiophen-3S-yl ester in 30 mL of dichloromethane was added 400 mg (1.2 mmol) of m-chloroperbenzoic acid (50 wt%) and the mixture
- 15 was stirred for 12 hours. The contents were diluted with 10 mL of 10% aqueous sodium metabisulfite and stirred for 30 minutes. The organic layer was washed with saturated sodium bicarbonate, dried over sodium sulfate, filtered and concentrated to yield 290 mg of crude product.
- 20 Purification by silica gel chromatography using an eluant of 10:10:1 ethyl acetate:hexane:methanol provided 260 mg of Carbamic acid, [2R-hydroxy-3-[(4-methoxyphenylsulfonyl)(2-methylpropyl)amino]-1S-(phenylmethyl)propyl-, 1,1-dioxotetrahydrothiophen-3S-yl ester, as a white
- 25 crystalline solid. m.p. = 69 ° C, m/z = 569 (M+H).

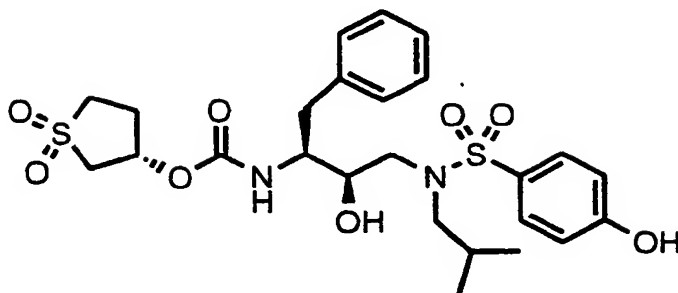
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Example 16E

5 Preparation of Carbamic acid, [2R-hydroxy-3-[(4-hydroxyphenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl-, tetrahydrothiophen-3S-yl ester.

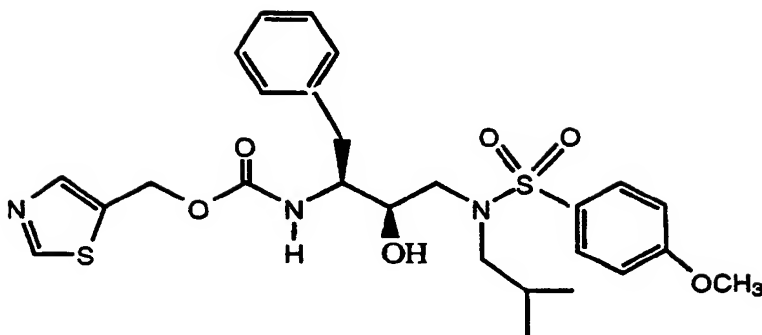
To a solution of 125 mg (1.2 mmol) of 3-S-
 10 hydroxythiophene, 250 μ L of anhydrous pyridine, and 1 mL of dry acetonitrile was added 307 mg (1.2 mmol) of N,N'-dimethylsuccinimidyl carbonate and this suspension was stirred for 45 minutes. To this clear solution was added a solution of 445 mg (1.0 mmol) [2R-hydroxy-3-[[4-
 15 hydroxyphenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propylamine in 1.0 mL of acetonitrile and stirred for 12 hours. The contents were concentrated, and the residue was partitioned between ethyl acetate and 5% aqueous potassium hydrogen sulfate. The organic layer
 20 was washed with saturated sodium bicarbonate and then brine, dried over sodium sulfate, filtered and concentrated to yield 460 mg of crude material. Purification by silica gel chromatography using an eluant of 10:10:1 ethyl acetate: hexane:methanol provided 235 mg
 25 of Carbamic acid, [2R-hydroxy-3-[(4-hydroxyphenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl-, tetrahydrothiophen-3S-yl ester, as a crystalline white solid. m.p. = 184-85°C, m/z = 529 (M+Li).

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Example 16F

- 5 Preparation of Carbamic acid, [2R-hydroxy-3-[(4-hydroxyphenylsulfonyl)(2-methylpropyl)amino]-1S-(phenylmethyl)propyl-, 1,1-dioxotetrahydrothiophen-3S-yl ester
- 10 To a solution of 125 mg (0.24 mmol) of carbamic acid, [2R-hydroxy-3-[(4-hydroxyphenylsulfonyl)(2-methylpropyl)amino]-1S-(phenylmethyl)propyl-, tetrahydrothiophen-3S-yl ester in 30 mL of dichloromethane was added 240 mg (0.7 mmol) of m-chloroperbenzoic acid (50 wt%) and the mixture
- 15 was stirred for 12 hours. The contents were diluted with 5 mL of 10% aqueous sodium metabisulfite and stirred for 30 minutes. The organic layer was washed with saturated sodium bicarbonate, dried over sodium sulfate, filtered and concentrated to yield 110 mg of crude product.
- 20 Purification by silica gel chromatography using an eluant of 1:1 to 2:1 ethyl acetate:hexane:methanol provided 100 mg of carbamic acid, [2R-hydroxy-3-[(4-hydroxyphenylsulfonyl)(2-methylpropyl)amino]-1S-(phenylmethyl)propyl-, 1,1-dioxotetrahydrothiophen-3S-yl-ester, as a white
- 25 crystalline solid, m.p.= 190°C, m/z= 561 (M+Li).

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Example 17A

5 Preparation of Carbamic acid, [2R-hydroxy-3-[[[4-
methoxyphenyl)sulfonyl](methylpropyl)aminol-1S-
10 (phenylmethyl)propyl]-, 5-thiazolylmethyl ester

Part A: Preparation of Methyl 2-aminothiazole-5-
10 carboxylate

Methyl chloroacetate 190 g (1.75 mol) and methyl formate
111 g (1.80 mol), were added dropwise to a suspension of
100 g (1.8 mol) of sodium methoxide in 450 mL of dry
15 toluene at 5°C over 2 hours. After an additional 2.5
hours at 0°C. The contents were diluted with 600 mL of
water and the layers separated. The aqueous phase was
acidified with 113 mL of concentrated hydrochloric acid.
The aqueous solution was placed in a 2 liter flask and
20 175 grams of thiourea was added and to solution was
heated to reflux for 1.45 hours. To the cooled solution
was added 25 g of DARCO activated charcoal and filtered
through filter paper. The crude dark yellow solution was
neutralized with 2.5 N sodium hydroxide upon which time
25 an amber solid precipitated which was filtered and air
dried to yield 147 g of desired methyl 2-aminothiazole-5-
carboxylate. m/e = 159 (M+H).

Part B: Preparation of Methyl 5-thiazolecarboxylate

To a solution of 35 mL (30.5 g, 260 mmol) of isoamyl nitrite in 120 mL of dioxane at 80°C under nitrogen, was slowly added a slurry of 20.0 g (126 mmol) of methyl 2-amino-5-thiazolecarboxylate over a 45 minute period. After refluxing for a further 1 hour, the solution was cooled, concentrated, dissolved in ethyl acetate, washed with saturated sodium bicarbonate, brine, dried over magnesium sulfate, filtered and concentrated to afford 28 g of the crude product. This was chromatographed on 400 g of silica gel using 20% ethyl acetate/hexane to afford 9.07 g of purified material, which was crystallized from methylene chloride/hexane to yield 7.64g of pure methyl 5-thiazolylcarboxylate, $m/e=144 (M+H)$.

Part C: Preparation of 5-thiazolemethanol

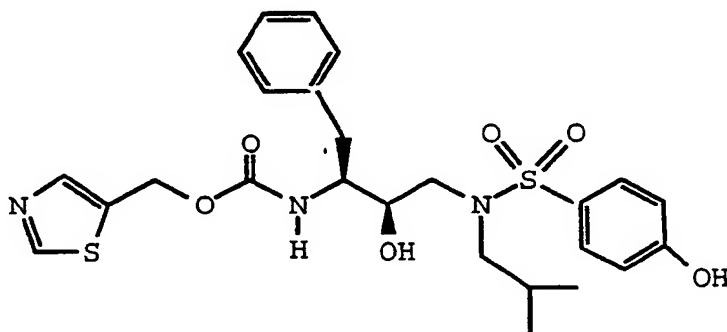
To a solution of 11.73 g (82 mmol) of methyl 5-thiazolylcarboxylate in 105 mL of anhydrous tetrahydrofuran at 0°C under nitrogen, was added 90 mL (90 mmol) of a 1.0M lithium aluminum hydride solution in diethyl ether over a 35 minute period. After stirring at room temperature for 30 minutes, the solution was cooled to 0°C, and carefully quenched by the addition of 3 mL of water, 3 mL of 20% sodium hydroxide solution, and 6 mL of water, then 100mL of tetrahydrofuran was added. After stirring for 1 hour, the mixture was filtered, the solid was washed with tetrahydrofuran, and the filtrate concentrated to afford 7.56 g of 5-thiazolylmethanol.

Part D: Preparation of Carbamic acid, [2R-hydroxy-3-[[[(4-methoxyphenyl)sulfonyl](methylpropyl)amino]-1S-(phenylmethyl)propyl]-, 5-(thiazolyl)methyl ester

To a solution of 115 mg (1.00 mmol) of 5-(hydroxymethyl)thiazole in 3 mL of anhydrous acetonitrile, was added 0.25 mL (0.25 g, 3.09 mmol) of pyridine and then 256 mg (1.03

mmol) of N,N'-disuccinimidyl carbonate at room temperature under nitrogen. After 45 minutes, 406 mg (1.00 mmol) of 2R-hydroxy-3-[(2-methylpropyl)(4-methoxyphenyl)sulfonyl]amino-1S-(phenylmethyl)propylamine was added. After stirring at room temperature for 15 hours, ethyl acetate was added, washed with water, saturated sodium bicarbonate and brine, dried over magnesium sulfate, filtered and concentrated to afford 500mg of crude product. This was chromatographed on silica gel using 80% ethyl acetate/hexane as eluent to afford 307 mg of a white solid, which was identified as the desired carbamic acid, [2R-hydroxy-3-[[[(4-methoxyphenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl-, 5-thiazolylmethyl ester, m/e = 548 (M+H).

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Example 17B

Preparation of Carbamic acid, [2R-hydroxy-3-[[[(4-hydroxyphenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl-, 5-thiazolylmethyl ester

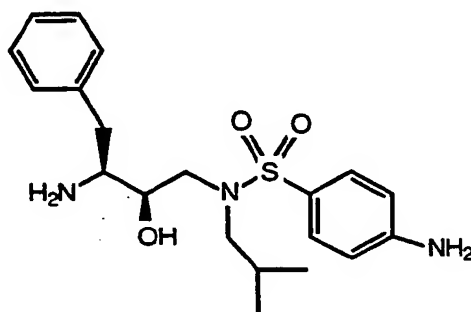
To a solution of 115 mg (1.00 mmol) of 5-(hydroxymethyl)thiazole in 3 mL of anhydrous acetonitrile, was added 0.25 mL (0.25 g, 3.09 mmol) of pyridine and then 256 mg (1.03 mmol) of N,N'-disuccinimidyl carbonate at room temperature under nitrogen. After 45 minutes, 392 mg (1.00 mmol) of 2R-hydroxy-3-[(2-methylpropyl)(4-hydroxyphenyl)sulfonyl]amino-1S-(phenylmethyl)propylamine was added. After stirring at room temperature for 15 hours, ethyl acetate was added, washed with water, saturated sodium bicarbonate and brine,

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dried over magnesium sulfate, filtered and concentrated to afford 450 mg of crude product. This was chromatographed on silica gel using 80% ethyl acetate/hexane as eluent to afford 270 mg of a white solid, which was identified as the
5 desired carbamic acid, [2R-hydroxy-3-[[[4-hydroxyphenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl-, 5-thiazolylmethyl ester, m/e =534 (M+H).

Example 18A

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Preparation of 2R-hydroxy-3-[[[4-aminophenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propylamine

15

Part A: Preparation of Carbamic acid, 2R-hydroxy-3-[[[4-nitrophenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl-, phenylmethyl ester

20 To a solution of 4.0 g (10.8 mmol) of N-[3S-benzyloxy carbonylamino-2R-hydroxy-4-phenyl]-N-isobutylamine in 50mL of anhydrous methylene chloride, was added 4.5mL (3.27g, 32.4 mmol) of triethylamine. The solution was cooled to 0°C and 2.63g (11.9 mmol) of 4-nitrobenzene
25 sulfonyl chloride was added, stirred for 30 minutes at 0°C, then for 1 hour at room temperature. Ethyl acetate was added, washed with 5% citric acid, saturated sodium bicarbonate, brine, dried and concentrated to yield 5.9 g of crude material. This was recrystallized from ethyl
30 acetate/hexane to afford 4.7 g of pure carbamic acid, [2R-hydroxy-3-[[[4-nitrophenyl)sulfonyl](2-methylpropyl)

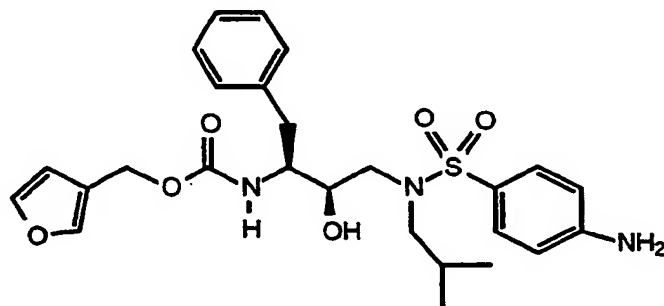
134

amino]-1S-(phenylmethyl)propyl-, phenylmethyl ester,
m/e=556(M+H).

Part B: Preparation of 2R-hydroxy-3-[[(4-aminophenyl)
5 sulfonyl] (2-methylpropyl) amino]-1S-(phenylmethyl)
propylamine

A solution of 3.0g (5.4 mmol) of carbamic acid, 2R-
hydroxy-3-[[(4-nitrophenyl) sulfonyl] (2-methylpropyl)
10 amino]-1S-(phenylmethyl)propyl-, phenylmethyl ester in 20
mL of ethyl acetate was hydrogenated over 1.5 g of 10%
palladium-on-carbon catalyst under 35 psig of hydrogen
for 3.5 hours. The catalyst was removed by filtration
and the solution concentrated to afford 2.05 g of the
15 desired 2R-hydroxy-3-[[(4-aminophenyl) sulfonyl] (2-
methylpropyl) amino]-1S-(phenylmethyl)propylamine,
m/e=392(M+H).

Example 18B



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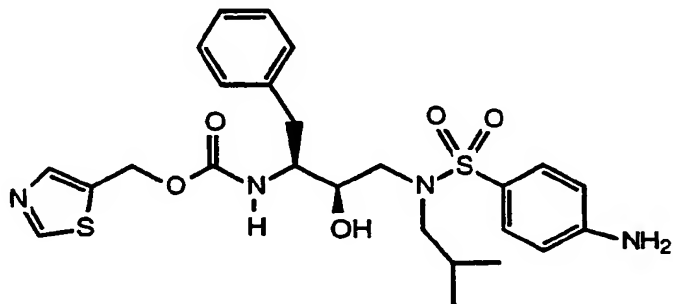
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Preparation of Carbamic acid, 2R-hydroxy-3-[[(4-
aminophenyl) sulfonyl] (2-methylpropyl) amino]-1S-
(phenylmethyl)propyl-, 3-furanylmethyl ester

To a solution of 104mg (1.06 mmol) of 3-(hydroxymethyl)
furan in 2 mL of anhydrous acetonitrile, was added 0.26
mL (0.25g, 3.18 mmol) of pyridine and then 277 mg (1.06
30 mmol) of N,N'-disuccinimidyl carbonate at room
temperature under nitrogen. After 45 minutes, 415 mg
(1.06 mmol) of 2R-hydroxy-3-[(2-methylpropyl)(4-

135

aminophenyl)sulfonyl]amino-1S-(phenylmethyl)propylamine was added. After stirring at room temperature for 72 hours, ethyl acetate was added, washed with 5% citric acid, saturated sodium bicarbonate and brine, dried over magnesium sulfate, filtered and concentrated to afford 550 mg of crude product. This was chromatographed on silica gel using 50% ethyl acetate/hexane as eluent to afford 230 mg of a white foam, which was identified as the desired carbamic acid, 2R-hydroxy-3-[[[4-aminophenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl-, 3-furanylmethyl ester, m/e = 522 (M+Li).

Example 18C

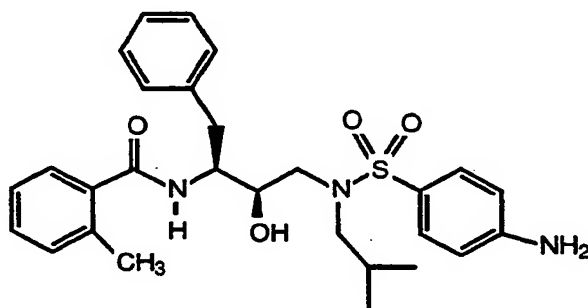
Preparation of Carbamic acid, 2R-hydroxy-3-[[[4-aminophenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl-, 5-thiazolylmethyl ester

To a solution of 118mg (1.03 mmol) of 5-(hydroxymethyl)thiazole in 3 mL of anhydrous acetonitrile, was added 0.25 mL (0.24g, 3.09 mmol) of pyridine and then 264 mg (1.03 mmol) of N,N'-disuccinimidyl carbonate at room temperature under nitrogen. After 45 minutes, 403 mg (1.03 mmol) of 2R-hydroxy-3-[(2-methylpropyl)(4-aminophenyl)sulfonyl]amino-1S-(phenylmethyl)propylamine was added. After stirring at room temperature for 15 hours, ethyl acetate was added, washed with 5% citric acid, saturated sodium bicarbonate and brine, dried over magnesium sulfate, filtered and concentrated to afford

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350 mg of crude product. This was chromatographed on silica gel using 80% ethyl acetate/hexane as eluent to afford 290 mg of a white solid, which was identified as the desired carbamic acid, 2R-hydroxy-3-[[[4-aminophenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl-, 5-thiazolylmethyl ester, m/e = 539 (M+Li).

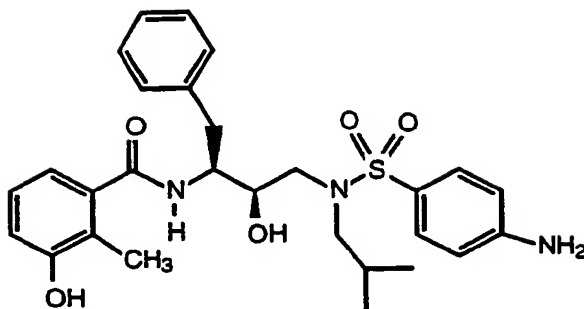
Example 18D



Preparation of Benzamide, N-[2R-hydroxy-3-[[[4-aminophenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-2-methyl

To a solution of 391 mg (1 mmol) of 2R-hydroxy-3-[[[2-methylpropyl)(4-aminophenyl)sulfonyl]amino]-1S-(phenylmethyl)propylamine in 3 mL of anhydrous methylene chloride, was added 0.42 mL (3 mmol) of triethylamine, then at room temperature, 0.12 mL (0.9 mmol) of ortho-toluoyl chloride was added. After 15 hours at room temp ethyl acetate was added, washed with 5% citric acid, saturated sodium bicarbonate, brine, dried, filtered and concentrated to afford 420 mg of crude material. This was chromatographed on 40 g of silica gel using 50% ethyl acetate/hexane to afford 368 mg of pure benzamide, N-[2R-hydroxy-3-[[[4-aminophenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-2-methyl, m/e=516(M+Li).

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Example 18E

5 Preparation of Benzamide, N-[2R-hydroxy-3-[[[4-
 aminophenyl)sulfonyl](2-methylpropyl)aminol-1S-
 (phenylmethyl)propyl]-3-hydroxy-2-methyl

Part A: Preparation of 3-Hydroxy-2-methylbenzoic Acid

10

A one-necked 100 mL round-bottomed flask (magnetic stirring) was charged with 1.0 gram (6.6 mM) 3-amino-2-methylbenzoic acid. A warm mixture of 2.3 mL conc. sulfuric acid in 4.3 mL water was added to the flask, the
15 resulting slurry was cooled below 15°C in an ice bath, and 6.6 grams of ice was added. The reaction mixture was treated via subsurface addition with a solution of 0.6 gram (8.6 mM) sodium nitrite in 6.6 mL ice water with the
20 reaction temperature maintained at 0-5°C during the addition. After stirring at 0-5°C for 30 min., a few crystals of urea were added to decompose the excess nitrite. The reaction mixture was then poured into a room temperature solution of 23.8 grams (102.3 mM) copper (II) nitrate hemipentahydrate in 200 mL water. With
25 vigorous stirring, the reaction mixture was treated with 0.9 gram (6.0 mM) copper (I) oxide. The reaction mixture foamed and changed from turquoise blue to dark green in color. Reaction was left stirring for 30 min. The reaction mixture was extracted with diethyl ether (3X),
30 and the organic extracts were combined. The organic extracts were concentrated to approximately one-fourth the original volume, then extracted with 25 mL 1N sodium

hydroxide solution. The layers were separated, and the dark-red aqueous layer was acidified to pH=2 using 1N hydrochloric acid solution. The acidified aqueous layer was then extracted with diethyl ether (3X), and the ether
5 extracts were combined, dried (MgSO₄), and concentrated to yield a reddish-colored oil. Purification by flash chromatography on silica gel using a gradient of 0-7% methanol/methylene chloride afforded 0.39 grams (36%) of a yellow solid.

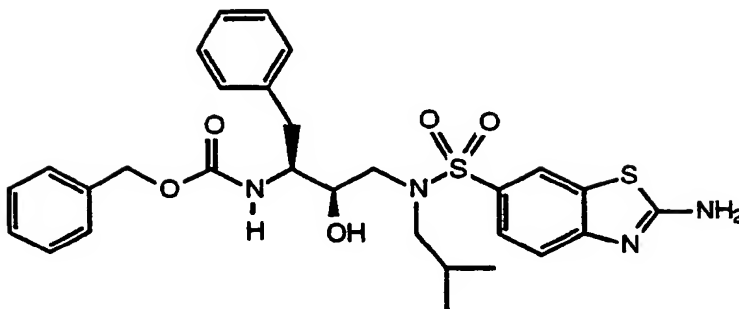
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Part B: Preparation of Benzamide, N-[2R-hydroxy-3-[[[4-aminophenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-3-hydroxy-2-methyl

15 To a solution of 175 mg (1.15 mmol) of 3-hydroxy-2-methylbenzoic acid and 203 mg (1.5 mmol) of N-hydroxybenzotriazole in 6 mL of anhydrous N,N-dimethylformamide at 0°C, was added 220 mg (1.15 mmol) of EDC. After 20 minutes of activation at 0°C and 1 hour at
20 room temperature, 392 mg (1.0 mmol) of 2R-hydroxy-3-[(2-methylpropyl)(4-aminophenyl)sulfonyl]amino-1S-(phenylmethyl)propylamine was added. After 15 hours at room temperature, ethyl acetate was added, washed with 5% citric acid, saturated sodium bicarbonate, brine, dried,
25 filtered and concentrated to afford 590 mg of crude material. This was chromatographed on silica gel using 50-80% ethyl acetate/methylene chloride as eluent to afford 255 mg of pure benzamide, N-[2R-hydroxy-3-[[[4-aminophenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-3-hydroxy-2-methyl, m/e = 526 (M+H).

30

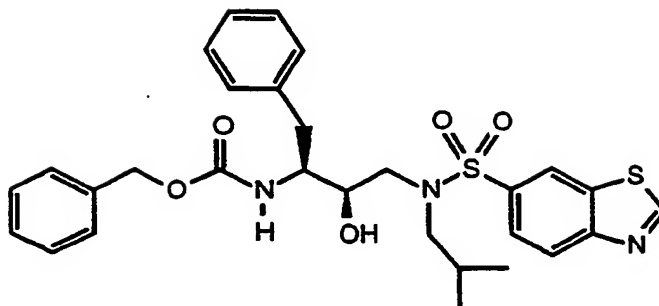
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Example 18F

5 Preparation of Carbamic acid, 2R-hydroxy-3-[[[2-
aminobenzothiazol-6-yl)sulfonyl](2-methylpropyl)amino]-
1S-(phenylmethyl)propyl-, phenylmethyl ester

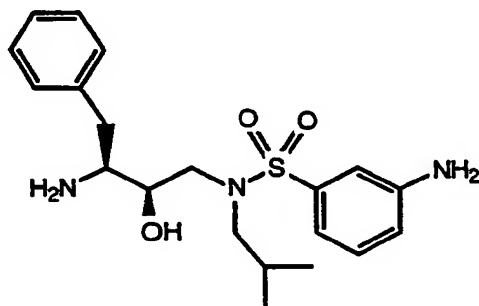
Carbamic acid, 2R-hydroxy-3-[[[4-aminophenyl)sulfonyl](2-
10 methylpropyl)amino]-1S-(phenylmethyl)propyl-,
phenylmethyl ester 0.30 g (0.571 mmol) was added to a
well mixed powder of anhydrous copper sulfate (1.20 g)
and potassium thiocyanate (1.50 g) followed by dry
methanol (6 mL) and the resulting black-brown suspension
15 was heated at reflux for 2 hrs. The reaction mixture was
filtered and the filtrate was diluted with water (5 mL)
and heated at reflux. Ethanol was added to the reaction
mixture, cooled and filtered. The filtrate upon
concentration afforded a residue which was
20 chromatographed (ethyl acetate:hexane 80:20) to afford
0.26 g (78%) of the desired compound as a solid.

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Example 18G

5 Preparation of Carbamic acid, 2R-hydroxy-3-[[[(2-aminobenzothiazol-6-yl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-, phenylmethyl ester

Carbamic acid, 2R-hydroxy-3-[[[(2-aminobenzothiazol-6-yl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-, phenylmethyl ester (0.25 g, 0.429 mmol) was added to a solution of isoamyl nitrite (0.116 mL, 0.858 mmol) in dioxane (5 mL) and the mixture was heated at 85°C. After the cessation of evolution of nitrogen, the reaction mixture was concentrated and the residue was purified by chromatography (hexane:ethyl acetate 5:3) to afford 0.130 g (53%) of the desired product as a solid.

Example 19A

Preparation of 2R-hydroxy-3-[[[(3-aminophenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propylamine

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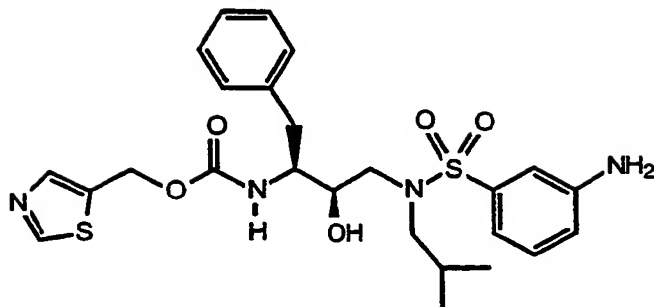
Part A: Preparation of Carbamic acid, [2R-hydroxy-3-[(3-nitrophenylsulfonyl)(2-methylpropyl)amino]-1S-(phenylmethyl)propyl-, phenylmethyl ester

5 To a solution of 1.1 g (3.0 mmol) of N-[3S-benzyloxy carbonylamino-2R-hydroxy-4-phenyl]-N-isobutylamine in 15mL of anhydrous methylene chloride, was added 1.3mL (0.94g, 9.3 mmol) of triethylamine. The solution was cooled to 0°C and 0.67 g (3.0 mmol) of 3-nitrobenzene
10 sulfonyl chloride was added, stirred for 30 minutes at 0°C, then for 1 hour at room temperature. Ethyl acetate was added, washed with 5% citric acid, saturated sodium bicarbonate, brine, dried and concentrated to yield 1.74 g of crude material. This was recrystallized from ethyl
15 acetate/hexane to afford 1.40 g of pure carbamic acid, [2R-hydroxy-3-[(3-nitrophenylsulfonyl)(2-methylpropyl)amino]-1S-(phenylmethyl)propyl-, phenylmethyl ester, m/e=562 (M+Li).

20 Part B: Preparation of [2R-hydroxy-3-[[[(3-aminophenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propylamine

A solution of 1.33g (2.5 mmol) of carbamic acid, [2R-hydroxy-3-[(3-nitrophenylsulfonyl)(2-methylpropyl)amino]-1S-(phenylmethyl)propyl-, phenylmethyl ester in 40 mL of
25 1:1 methanol/tetrahydrofuran was hydrogenated over 0.70 g of 10% palladium-on-carbon catalyst under 40 psig of hydrogen for 1.5 hours. The catalyst was removed by
30 filtration and the solution concentrated to afford 0.87 g of the desired [2R-hydroxy-3-[[[(3-aminophenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propylamine.

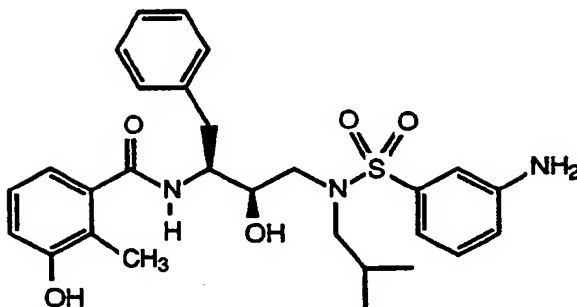
142

Example 19B

5 Preparation of Carbamic acid, 2R-hydroxy-3-[[[3-aminophenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl-, 5-thiazolylmethyl ester

To a solution of 133mg (1.15 mmol) of 5-(hydroxymethyl)
10 thiazole in 3 mL of anhydrous acetonitrile, was added
0.30 mL (0.29g, 3.7 mmol) of pyridine and then 296 mg
(1.15 mmol) of N,N'-disuccinimidyl carbonate at room
temperature under nitrogen. After 60 minutes, 460 mg
(1.18 mmol) of 2R-hydroxy-3-[(2-methylpropyl)(3-
15 aminophenyl)sulfonyl]amino-1S-(phenylmethyl)propylamine
was added. After stirring at room temperature for 15
hours, ethyl acetate was added, washed with 5% citric
acid, saturated sodium bicarbonate and brine, dried over
magnesium sulfate, filtered and concentrated to afford
20 480 mg of crude product. This was chromatographed on
silica gel using 50-80% ethyl acetate/hexane as eluent to
afford 422 mg of a white solid, which was identified as
the desired carbamic acid, 2R-hydroxy-3-[(3-aminophenyl
sulfonyl)(2-methylpropyl)amino]-1S-(phenylmethyl)propyl-,
25 5-thiazolylmethyl ester, m/e = 539 (M+Li).

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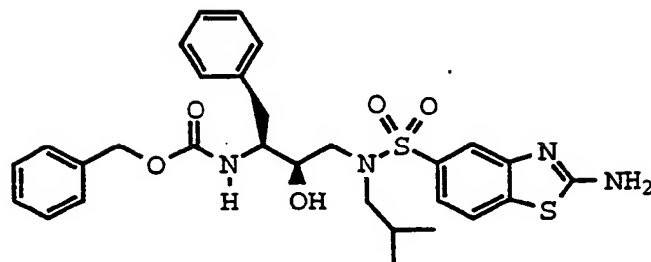
Example 19C

5 Preparation of Benzamide, N-[2R-hydroxy-3-[[[3-
aminophenyl)sulfonyl](2-methylpropyl)amino]-1S-
(phenylmethyl)propyl]-3-hydroxy-2-methyl

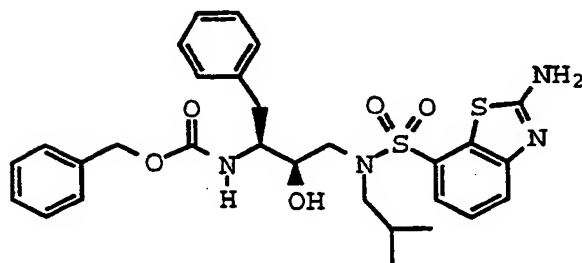
To a solution of 134 mg (0.88 mmol) of 3-hydroxy-2-
10 methylbenzoic acid and 155 mg (1.15 mmol) of N-
hydroxybenzotriazole in 5 mL of anhydrous N,N-
dimethylformamide at 0°C, was added 167 mg (0.88 mmol) of
EDC. After 20 minutes of activation at 0°C and 1 hour at
room temperature, 300 mg (1.0 mmol) of 2R-hydroxy-3-[(2-
15 methylpropyl)(3-aminophenyl)sulfonyl]amino-1S-
(phenylmethyl)propylamine was added. After 15 hours at
room temperature, ethyl acetate was added, washed with 5%
citric acid, saturated sodium bicarbonate, brine, dried,
filtered and concentrated to afford 330 mg of crude
20 material. This was chromatographed on silica gel using
30-70% ethyl acetate/methylene chloride as eluent to
afford 230 mg of pure benzamide, N-[2R-hydroxy-3-[[[3-
aminophenyl)sulfonyl](2-methylpropyl)amino]-1S-
(phenylmethyl)propyl]-3-hydroxy-2-methyl.

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Example 19D

and



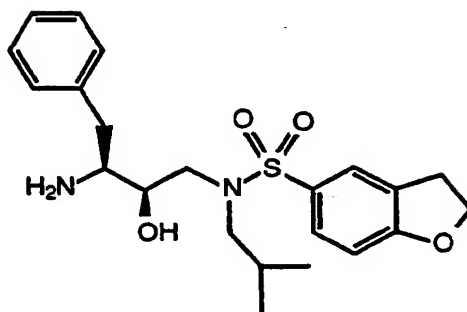
- 5 Preparation of Carbamic acid, 2R-hydroxy-3-[[[(2-amino
benzothiazol-5-yl)sulfonyl](2-methylpropyl)amino]-1S-
(phenylmethyl)propyl]-, phenylmethyl ester; and Carbamic
acid, 2R-hydroxy-3-[[[(2-aminobenzothiazol-7-yl)sulfonyl]
(2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-,
10 phenylmethyl ester

The carbamic acid, 2R-hydroxy-3-[(3-aminophenylsulfonyl)-
 (2-methylpropyl)amino]-1S-(phenylmethyl)propyl-,
 phenylmethyl ester 0.36 g (0.685 mmol) was added to a
 15 well mixed powder of anhydrous copper sulfate (1.44 g)
 and potassium thiocyanate (1.80 g) followed by dry
 methanol (10 mL) and the resulting black-brown suspension
 was heated at reflux for 2 hrs. The reaction mixture was
 filtered and the filtrate was diluted with water (5 mL)
 20 and heated at reflux. Ethanol was added to the reaction
 mixture, cooled and filtered. The filtrate upon
 concentration afforded a residue which was
 chromatographed (ethyl acetate:hexane 1:1) to afford 0.18
 g (45%) of the 7-isomer as a solid. Further elution of

the column with (ethyl acetate:hexane 3:2) afforded 0.80 g (20%) afforded the 5-isomer as a solid.

Example 20A

5



Preparation of 2R-hydroxy-3-[[[(2,3-dihydrobenzofuran-5-yl)sulfonyl]](2-methylpropyl)amino]-1S-(phenylmethyl)propylamine

10

Part A: Preparation of 5-(2,3-dihydrobenzofuranyl)sulfonyl chloride

15 To a solution of 3.35g of anhydrous N,N-dimethylformamide at 0°C under nitrogen was added 6.18 g of sulfuryl chloride, whereupon a solid formed. After stirring for 15 minutes, 4.69 g of 2,3-dihydrobenzofuran was added, and the mixture heated at 100°C for 2 hours. The
20 reaction was cooled, poured into ice water, extracted with methylene chloride, dried over magnesium sulfate, filtered and concentrated the crude material. This was recrystallized from ethyl acetate to afford 2.45 g of 5-(2,3-dihydrobenzofuranyl)sulfonyl chloride.

25

Part B: Preparation of Carbamic acid, 2R-hydroxy-3-[[[(2,3-dihydrobenzofuran-5-yl)sulfonyl]](2-methylpropyl)amino]-1S-(phenylmethyl)propyl-, phenylmethyl ester

30 To a solution of 1.11 g (3.0 mmol) of N-[3S-benzyloxy carbonylamino-2R-hydroxy-4-phenyl]-N-isobutylamine in 20mL of anhydrous methylene chloride, was added 1.3mL

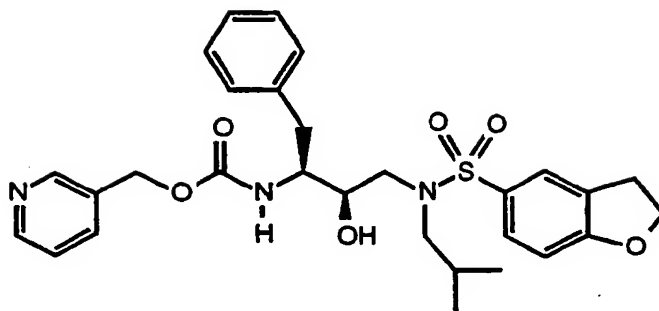
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(0.94 g, 9.3 mmol) of triethylamine. The solution was cooled to 0°C and 0.66 g of 5-(2,3-dihydrobenzofuranyl) sulfonyl chloride was added, stirred for 15 minutes at 0°C, then for 2 hour at room temperature. Ethyl acetate was added, washed with 5% citric acid, saturated sodium bicarbonate, brine, dried and concentrated to yield 1.62 g of crude material. This was recrystallized from diethyl ether to afford 1.17 g of pure carbamic acid, [2R-hydroxy-3-[[(2,3-dihydrobenzofuran-5-yl) sulfonyl] (2-methylpropyl) amino]-1S-(phenylmethyl) propyl-, phenylmethyl ester.

Part C: Preparation of [2R-hydroxy-3-[[(2,3-dihydro benzofuran-5-yl) sulfonyl] (2-methylpropyl) amino]-1S-(phenylmethyl) propylamine

A solution of 2.86 g of carbamic acid, [2R-hydroxy-3-[[(2,3-dihydrobenzofuran-5-yl) sulfonyl] (2-methylpropyl) amino]-1S-(phenylmethyl) propyl-, phenylmethyl ester in 30 mL of tetrahydrofuran was hydrogenated 0.99g of 10% palladium-on-carbon under 50 psig of hydrogen for 16 hours. The catalyst was removed by filtration and the filtrate concentrated to afford 1.99 g of the desired [2R-hydroxy-3-[[(2,3-dihydrobenzofuran-5-yl) sulfonyl] (2-methylpropyl) amino]-1S-(phenylmethyl) propylamine.

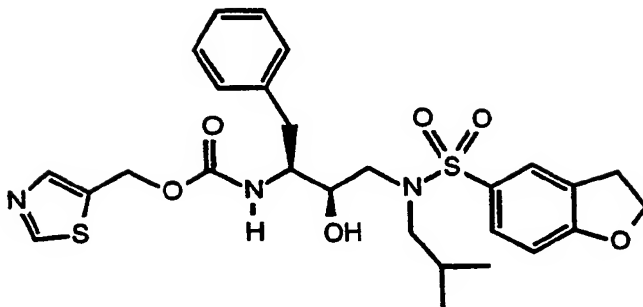
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Example 20B

5 Preparation of Carbamic acid, [2R-hydroxy-3-[[2,3-
10 dihydrobenzofuran-5-yl)sulfonyl](2-methylpropyl)amino]-
15 1S-(phenylmethyl)propyl-, 3-pyridylmethyl ester

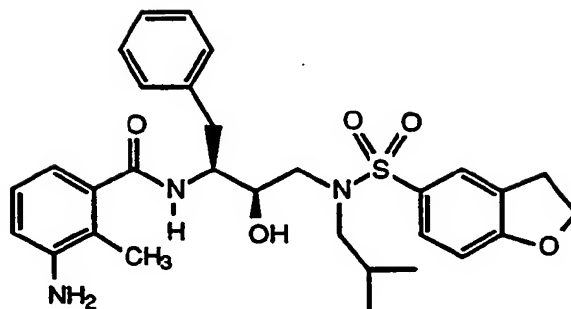
To a solution of 110 mg of 3-pyridylcarbinol in 3 mL of
10 anhydrous acetonitrile, was added 0.24g of anhydrous
pyridine and then 260 mg of N,N'-disuccinimidyl carbonate
at room temperature under nitrogen. After 45 minutes,
420 mg of 2R-hydroxy-3-[(2-methylpropyl)(2,3-
15 dihydrobenzofuran-5-yl)sulfonyl]amino-1S-(phenylmethyl)
propylamine was added. After stirring at room
temperature for 20 hours, ethyl acetate was added, washed
with 5% citric acid, saturated sodium bicarbonate and
brine, dried over magnesium sulfate, filtered and
concentrated to afford 320 mg of crude product. This was
20 chromatographed on silica gel using 50% ethyl
acetate/hexane as eluent to afford 260 mg of a white
solid, which was identified as the desired carbamic acid,
[2R-hydroxy-3-[[2,3-dihydrobenzofuran-5-yl)sulfonyl](2-
methylpropyl)amino]-1S-(phenylmethyl)propyl-, 3-
25 pyridylmethyl ester.

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Example 20C

5 Preparation of Carbamic acid, [2R-hydroxy-3-[[(2,3-
10 dihydrobenzofuran-5-yl)sulfonyl](2-methylpropyl)amino]-
15 1S-(phenylmethyl)propyl-, 5-thiazolylmethyl ester

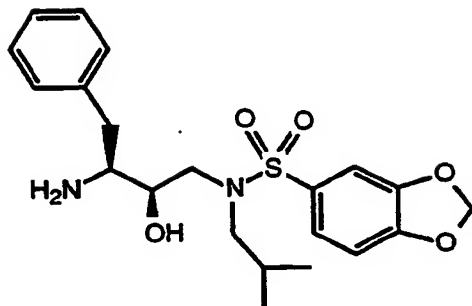
To a solution of 66 mg of 5-(hydroxymethyl)thiazole in 3
10 mL of anhydrous acetonitrile, was added 0.14g of
anhydrous pyridine and then 150 mg of N,N'-disuccinimidyl
carbonate at room temperature under nitrogen. After 45
minutes, 240 mg of 2R-hydroxy-3-[(2-methylpropyl)(2,3-
dihydrobenzofuran-5-yl)sulfonyl]amino-1S-(phenylmethyl)
15 propylamine was added. After stirring at room
temperature for 20 hours, ethyl acetate was added, washed
with 5% citric acid, saturated sodium bicarbonate and
brine, dried over magnesium sulfate, filtered and
concentrated to afford 220 mg of crude product. This was
20 chromatographed on silica gel using 50% ethyl
acetate/hexane as eluent to afford 120 mg of a white
solid, which was identified as the desired carbamic acid,
[2R-hydroxy-3-[[(2,3-dihydrobenzofuran-5-yl)sulfonyl](2-
methylpropyl)amino]-1S-(phenylmethyl)propyl-, 5-
25 thiazolylmethyl ester.

Example 20D

5 Preparation of Benzamide, N-[2R-hydroxy-3-[[[2,3-
dihydrobenzofuran-5-yl)sulfonyl](2-methylpropyl)amino]-
1S-(phenylmethyl)propyl]-3-amino-2-methyl-

To a solution of 175 mg of 3-amino-2-methylbenzoic acid
 10 in 2 mL of anhydrous N,N-dimethylformamide at 0°C, was
 added 200 mg of N-hydroxybenzotriazole and then 210 mg of
 EDC. After 20 minutes of activation, 405 mg of 2R-
 hydroxy-3-[[[2,3-dihydrobenzofuran-5-yl)sulfonyl](2-
 methylpropyl)amino]-1S-(phenylmethyl)propylamine was
 15 added. After stirring at room temperature for 16 hours,
 ethyl acetate was added, washed with 5% citric acid,
 sodium bicarbonate, brine, dried over magnesium sulfate,
 filtered and concentrated to afford 225 mg of crude
 product. This was chromatographed on silica gel using
 20 50% ethyl acetate/hexane to afford 140 mg of the desired
 benzamide, N-[2R-hydroxy-3-[[[2,3-dihydrobenzofuran-5-
 yl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)
 propyl]-3-amino-2-methyl, m/e=552 (M+H).

150

Example 21A

5 Preparation of 2R-hydroxy-3-[[[(1,3-benzodioxol-5-yl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propylamine

10 Part A: Preparation of (1,3-Benzodioxol-5-yl)sulfonyl chloride

To a solution of 4.25 g of anhydrous N,N-dimethylformamide at 0°C under nitrogen was added 7.84g of sulfonyl chloride, whereupon a solid formed. After
 15 stirring for 15 minutes, 6.45 g of 1,3-benzodioxole was added, and the mixture heated at 100°C for 2 hours. The reaction was cooled, poured into ice water, extracted with methylene chloride, dried over magnesium sulfate, filtered and concentrated to give 7.32 g of crude
 20 material as a black oil. This was chromatographed on silica gel using 20% methylene chloride/hexane to afford 1.9 g of (1,3-benzodioxol-5-yl)sulfonyl chloride.

25 Part B: Preparation of Carbamic acid, 2R-hydroxy-3-[[[(1,3-benzodioxol-5-yl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl-, phenylmethyl ester

To a solution of 3.19 g (8.6 mmol) of N-[3S-benzyloxy carbonylamino-2R-hydroxy-4-phenyl]-N-isobutylamine in
 30 40mL of anhydrous methylene chloride, was added 0.87g of triethylamine. The solution was cooled to 0°C and 1.90g of (1,3-benzodioxol-5-yl)sulfonyl chloride was added,

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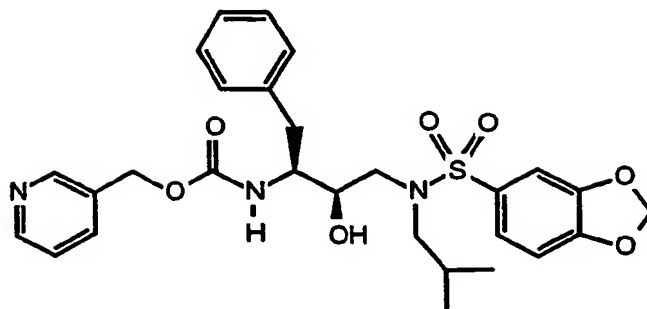
stirred for 15 minutes at 0°C, then for 17 hours at room temperature. Ethyl acetate was added, washed with 5% citric acid, saturated sodium bicarbonate, brine, dried and concentrated to yield crude material. This was

5 recrystallized from diethyl ether/hexane to afford 4.77 g of pure carbamic acid, 2R-hydroxy-3-[[(1,3-benzodioxol-5-yl)sulfonyl] (2-methylpropyl)amino]-1S-(phenylmethyl)propyl-, phenylmethyl ester.

10 Part C: Preparation of 2R-hydroxy-3-[[(1,3-benzodioxol-5-yl)sulfonyl] (2-methylpropyl)amino]-1S-(phenylmethyl)propylamine

A solution of 4.11 g of carbamic acid, 2R-hydroxy-3-
15 [[(1,3-benzodioxol-5-yl)sulfonyl] (2-methylpropyl)amino]-1S-(phenylmethyl)propyl-, phenylmethyl ester in 45 mL of tetrahydrofuran and 25 mL of methanol was hydrogenated over 1.1 g of 10% palladium-on-carbon under 50 psig of hydrogen for 16 hours. The catalyst was removed by
20 filtration and the filtrate concentrated to afford 1.82g of the desired 2R-hydroxy-3-[[(1,3-benzodioxol-5-yl)sulfonyl] (2-methylpropyl)amino]-1S-(phenylmethyl)propylamine.

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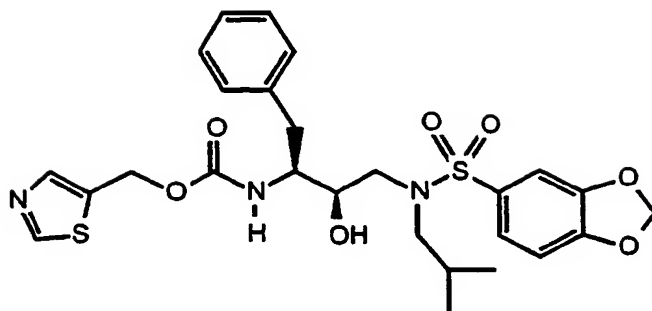
Example 21B

5 Preparation of Carbamic acid, 2R-hydroxy-3-[[[(1,3-benzodioxol-5-yl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl-, 3-pyridylmethyl ester

To a solution of 110 mg of 3-pyridylcarbinol in 3 mL of
10 anhydrous acetonitrile, was added 0.24 g of anhydrous pyridine and then 260 mg of N,N'-disuccinimidyl carbonate at room temperature under nitrogen. After 45 minutes, 410 mg of 2R-hydroxy-3-[[[(1,3-benzodioxol-5-yl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propylamine was added. After stirring at
15 room temperature for 20 hours, ethyl acetate was added, washed with 5% citric acid, saturated sodium bicarbonate and brine, dried over magnesium sulfate, filtered and concentrated to afford 330 mg of crude product. This was
20 chromatographed on silica gel using 50% ethyl acetate/hexane as eluent to afford 160 mg of a white solid, which was identified as the desired carbamic acid, [2R-hydroxy-3-[[[(1,3-benzodioxol-5-yl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl-, 3-pyridylmethyl ester, m/e=562 (M+Li).

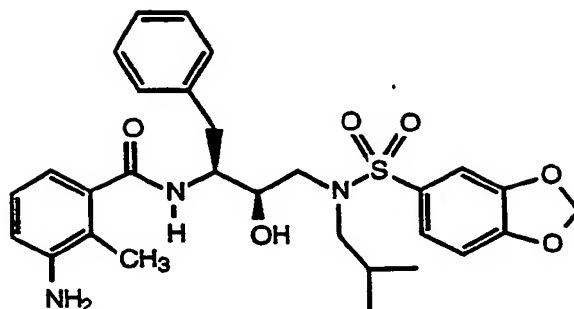
25

153

Example 21C

5 Preparation of Carbamic acid, 2R-hydroxy-3-[[[(1,3-benzodioxol-5-yl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-, 5-thiazolylmethyl ester

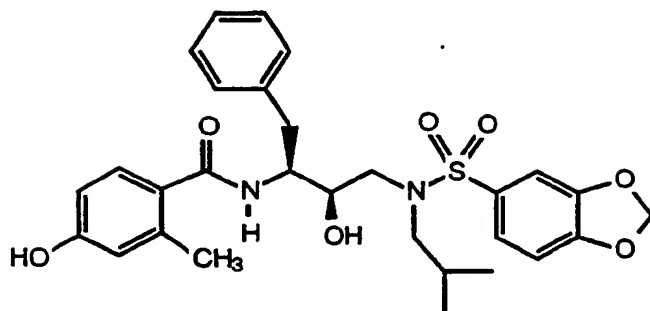
To a solution of 85 mg (0.8 mmol) of 5-(hydroxymethyl)
10 thiazole in 2.2 mL of anhydrous acetonitrile, was added
0.18 mL (2.2 mmol) of anhydrous pyridine and then 189 mg
(0.74 mmol) of N,N'-disuccinimidyl carbonate at room
temperature under nitrogen. After 45 minutes, 310 mg of
15 2R-hydroxy-3-[[[(1,3-benzodioxol-5-yl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propylamine was
added. After stirring at room temperature for 20 hours,
ethyl acetate was added, washed with 5% citric acid,
saturated sodium bicarbonate and brine, dried over
magnesium sulfate, filtered and concentrated to afford
20 300 mg of crude product. This was chromatographed on
silica gel using 50% ethyl acetate/hexane as eluent to
afford 150 mg of a white solid, which was identified as
the desired carbamic acid, 2R-hydroxy-3-[[[(1,3-benzodioxol-5-yl)sulfonyl](2-methylpropyl)amino]-1S-
25 (phenylmethyl)propyl]-, 5-thiazolylmethyl ester,
m/e=568 (M+Li).

Example 21D

5 Preparation of Benzamide, N-[2R-hydroxy-3-[[[(1,3-benzodioxol-5-yl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-3-amino-2-methyl

To a solution of 175 mg of 3-amino-2-methylbenzoic acid
 10 in 2 mL of anhydrous N,N-dimethylformamide at 0°C, was added 200 mg of N-hydroxybenzotriazole and then 210 mg of EDC. After 20 minutes of activation, 410 mg of 2R-hydroxy-3-[[[(1,3-benzodioxol-5-yl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propylamine was
 15 added. After stirring at room temperature for 16 hours, ethyl acetate was added, washed with 5% citric acid, sodium bicarbonate, brine, dried over magnesium sulfate, filtered and concentrated to afford 500 mg of crude product. This was chromatographed on silica gel using
 20 50% ethyl acetate/hexane to afford 310 mg of the desired benzamide, N-[2R-hydroxy-3-[[[(1,3-benzodioxol-5-yl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-3-amino-2-methyl, m/e=560 (M+Li).

155

Example 21E

- 5 Preparation of Benzamide, N-[2R-hydroxy-3-[[[1,3-
benzodioxol-5-yl)sulfonyl](2-methylpropyl)aminol-1S-
(phenylmethyl)propyl]-4-hydroxy-2-methyl

10 Part A: Preparation of 2-Trimethylsilyloxy-1,3-
 cyclohexadiene

A 100 mL round bottom flask equipped with magnetic stir
 bar, addition funnel, and N₂ inlet was charged with 40 mL
 dry THF and 8.3 mL diisopropyl amine. The solution was
 15 cooled to -78°C and charged with 23.8 mL of 2.5M nBuLi in
 Hexane. After 10 minutes a solution of 5.2 g
 cyclohexenone in 10 mL THF was added dropwise. The
 reaction was stirred 10 minutes at -78°C and quenched
 with 7.5 mL trimethylsilyl chloride. The reaction was
 20 stirred 15 minutes and then partitioned between diethyl
 ether and cold saturated aqueous sodium bicarbonate. The
 combined organic layers were dried over sodium sulfate
 and concentrated in vacuo to a yellow oil. Short path
 distillation (BP 27-29°C/0.5mm) afforded 6.0 g (66%) of
 25 2-Trimethylsilyloxy-1,3-Cyclohexadiene.

Part B: Preparation of Methyl (2-methyl-4-
 trimethylsilyloxy)benzoate

30 A 50 mL round bottom flask equipped with magnetic stir
 bar and condenser was charged with 6.0 g of 2-
 trimethylsilyloxy-1,3-cyclohexadiene, 3.5 g methyl

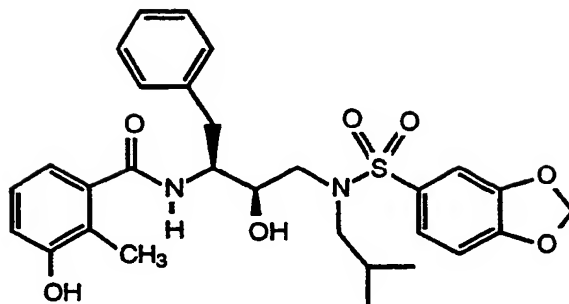
tetrolate in 3 mL dry toluene. The reaction was heated to 150°C for 50 hours at which point ¹H-NMR indicated no starting diene. The reaction was concentrated in vacuo to provide 5.7 g (67%) methyl 2-methyl-4-trimethylsilyloxybenzoate.

Part C: Preparation of 4-Hydroxy-2-methylbenzoic acid

A 100mL round bottom flask equipped with magnetic stir bar was charged with 5.7 g methyl 2-methyl-4-trimethylsilyloxybenzoate and 2.0 g LiOH in 40 mL methanol and 10 mL water. After 2 hours at reflux the reaction was poured into 10 mL concentrated HCl and then 100 g ice. Extraction with ethyl acetate followed by concentration in vacuo gave a crude solid (70:30) product:starting material. Flash Chromatography using 50-50 ethyl acetate/hexanes as an eluent gave 1.15 g 2-methyl-4-hydroxybenzoic acid, m/e=193(M+H).

Part D: Preparation of Benzamide, N-[2R-hydroxy-3-[[[(1,3-benzodioxol-5-yl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-4-hydroxy-2-methyl

To a solution of 175 mg of 4-hydroxy-2-methylbenzoic acid in 2 mL of anhydrous N,N-dimethylformamide at 0°C, was added 200 mg of N-hydroxybenzotriazole and then 220 mg of EDC. After 20 minutes of activation, 450 mg of 2R-hydroxy-3-[[[(1,3-benzodioxol-5-yl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propylamine was added. After stirring at room temperature for 16 hours, ethyl acetate was added, washed with 5% citric acid, sodium bicarbonate, brine, dried over magnesium sulfate, filtered and concentrated to afford crude product. This was chromatographed on silica gel using 50% ethyl acetate/hexane to afford 102 mg of the desired benzamide, N-[2R-hydroxy-3-[[[(1,3-benzodioxol-5-yl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-4-hydroxy-2-methyl.

Example 21F

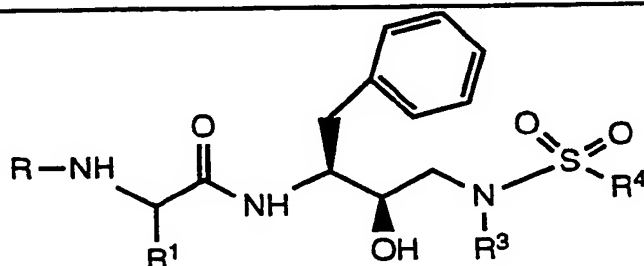
5

Preparation of Benzamide, N-[2R-hydroxy-3-[[[(1,3-benzodioxol-5-yl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-3-hydroxy-2-methyl

- 10 To a solution of 187 mg (1.23 mmol) of 3-hydroxy-2-methylbenzoic acid and 217 mg (1.61 mmol) of N-hydroxybenzotriazole in 6 mL of anhydrous N,N-dimethylformamide at 0°C, was added 236 mg (1.23 mmol) of EDC. After 20 minutes of activation at 0°C and 1 hour at
- 15 room temperature, 450 mg (1.07 mmol) of 2R-hydroxy-3-[[[(1,3-benzodioxol-5-yl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propylamine was added. After 15 hours at room temperature, ethyl acetate was added, washed with 5% citric acid, saturated sodium bicarbonate, brine,
- 20 dried, filtered and concentrated to afford 650 mg of crude material. This was chromatographed on silica gel using 0-25% ethyl acetate/methylene chloride as eluent to afford 390 mg of pure benzamide, N-[2R-hydroxy-3-[[[(1,3-benzodioxol-5-yl)sulfonyl](2-methylpropyl)amino]-1S-
- 25 (phenylmethyl)propyl]-3-hydroxy-2-methyl, m/e=561(M+Li).

Example 22

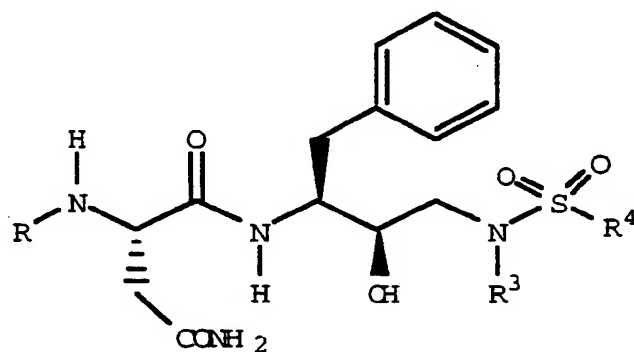
Following the procedures of Examples 1-21, the compounds shown in Tables 3, 5A and 5B were prepared and in Tables 4 through 17 can be prepared.

TABLE 3

10

Entry No.	R	R ¹	R ³	R ⁴
1	Cbz	t-Butyl	i-Amyl	Methyl
2	N,N-Dimethylglycine	t-Butyl	i-Amyl	Methyl
3	Cbz	i-Propyl	i-Amyl	Phenyl
15 4	Cbz	sec-Butyl	i-Amyl	Phenyl
5	Cbz	CH ₂ C(O)NH ₂	n-Propyl	Phenyl
6	N-Methylglycine	t-Butyl	i-Amyl	Phenyl
7	Cbz	t-Butyl	i-Butyl	Phenyl
8	N,N-Dimethylglycine	t-Butyl	i-Amyl	Phenyl
20 9	N-Methylglycine	t-Butyl	i-Amyl	Phenyl
10	N,N-Dimethylglycine	t-Butyl	i-Butyl	(4-OCH ₃) Phenyl
11	N-Methylglycine	t-Butyl	i-Butyl	(4-OCH ₃) Phenyl

TABLE 4



5





Entry	No.	R	R ³	R ⁴
10	1	Cbza	CH ₃	n-Butyl
	2	Cbz	i-Butyl	CH ₃
	3	Cbz	i-Butyl	n-Butyl
	4	Qb	i-Butyl	n-Butyl
	5	Cbz	i-Propyl	n-Butyl
15	6	Q	i-Propyl	n-Butyl
	7	Cbz	C ₆ H ₅	n-Butyl
	8	Cbz	-CH ₂ - 	n-Butyl
	9	Cbz	-CH ₂ - 	n-Butyl
	10	Q	-CH ₂ - 	n-Butyl
20	11	Cbz		n-Butyl
	12	Cbz	i-Butyl	n-Propyl

TABLE 4 (Cont'd.)








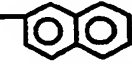
Entry No.	R	R ³	R ⁴
5			
13	Cbz	i-Butyl	-CH ₂ CH(CH ₃) ₂
14	Cbz	(R)-CH(CH ₃)- 	n-Butyl
15	Cbz	CH ₂ - 	i-Propyl
16	Cbz	-CH ₂ - 	-CH ₂ CH ₂ CH(CH ₃) ₂
10 17	Cbz	i-Butyl	-CH ₂ CH ₃
18	Cbz	i-Butyl	-CH(CH ₃) ₂
19	Cbz	i-Butyl	
20	Q	-Butyl	
21	Cbz	-CH ₂ - 	-(CH ₂) ₂ CH(CH ₃) ₂
15 22	Cbz	(CH ₂) ₂ CH(CH ₃) ₂	-CH(CH ₃) ₂
23	Q	i-Butyl	-CH(CH ₃) ₂
24	Cbz	i-Butyl	-C(CH ₃) ₃
25	Q	i-Butyl	-C(CH ₃) ₃
26	Cbz	-CH ₂ - 	-C(CH ₃) ₃
20 27	Q	-CH ₂ - 	-C(CH ₃) ₃
28	Cbz	-(CH ₂) ₂ CH(CH ₃) ₂	-C(CH ₃) ₃
29	Q	-(CH ₂) ₂ CH(CH ₃) ₂	-C(CH ₃) ₃
30	Cbz	-CH ₂ C ₆ H ₅	-C(CH ₃) ₃
31	Q	-CH ₂ C ₆ H ₅	-C(CH ₃) ₃
25 32	Cbz	-(CH ₂) ₂ C ₆ H ₅	-C(CH ₃) ₃
33	Cbz	-(CH ₂) ₂ C ₆ H ₅	-C(CH ₃) ₃
34	Cbz	n-Butyl	-C(CH ₃) ₃

TABLE 4 (Cont'd.)







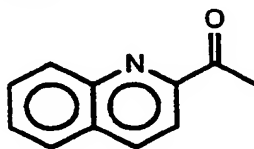
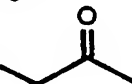
Entry No.	R	R ³	R ⁴	
5				
35	Cbz	n-Pentyl	-C(CH ₃) ₃	
36	Cbz	n-Hexyl	-C(CH ₃) ₃	
37	Cbz	-CH ₂ - 	-C(CH ₃) ₃	
38	Cbz	-CH ₂ C(CH ₃) ₃	-C(CH ₃) ₃	
10	39	Q	-CH ₂ C(CH ₃) ₃	-C(CH ₃) ₃
40	Cbz	-CH ₂ CH ₂ -N 	-C(CH ₃) ₃	
41	Cbz	-CH ₂ C ₆ H ₅ OCH ₃ (para)	-C(CH ₃) ₃	
42	Cbz	-CH ₂ - 	-C(CH ₃) ₃	
43	Cbz	-CH ₂ - 	-C(CH ₃) ₃	
15	44	Cbz	-(CH ₂) ₂ C(CH ₃) ₃	-C(CH ₃) ₃
45	Q	-(CH ₂) ₂ C(CH ₃) ₃	-C(CH ₃) ₃	
46	Cbz	-(CH ₂) ₄ OH	-C(CH ₃) ₃	
47	Q	-(CH ₂) ₄ OH	-C(CH ₃) ₃	
48	Q	-CH ₂ - 	-C(CH ₃) ₃	
20	49	Q	-CH ₂ - 	-C(CH ₃) ₃
50	Cbz	-CH ₂ CH(CH ₃) ₂	-C ₆ H ₅	
51		-CH ₂ CH(CH ₃) ₂	-C ₆ H ₅	
52	(CH ₃) ₂ N 	-CH ₂ CH(CH ₃) ₂	-C ₆ H ₅	

TABLE 4 (Cont'd.)

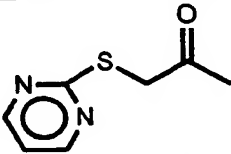
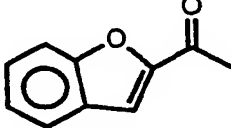
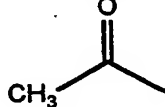
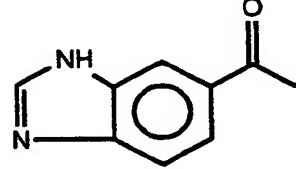
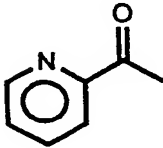
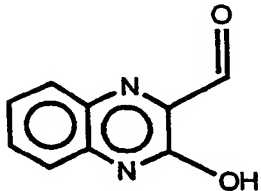
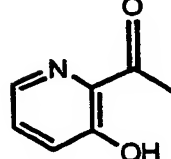
Entry	No.	R	R ³	R ⁴
5				
53			-CH ₂ CH(CH ₃) ₂	-C ₆ H ₅
54			-CH ₂ CH(CH ₃) ₂	-C ₆ H ₅
55			-CH ₂ CH(CH ₃) ₂	-C ₆ H ₅
56			-CH ₂ CH(CH ₃) ₂	-C ₆ H ₅
10	57		-CH ₂ CH(CH ₃) ₂	-C ₆ H ₅
58			-CH ₂ CH(CH ₃) ₂	-C ₆ H ₅
59			-CH ₂ CH(CH ₃) ₂	-C ₆ H ₅

TABLE 4 (Cont'd.)

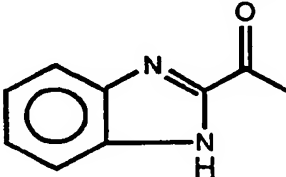
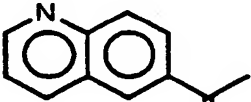
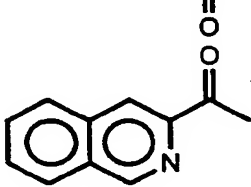
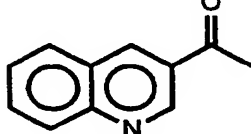
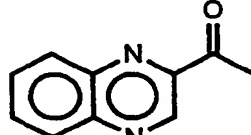
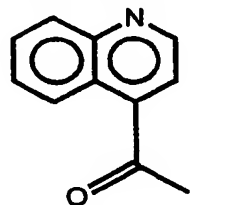
5	Entry No.	R	R ³	R ⁴
	60		-CH ₂ CH(CH ₃) ₂	-C ₆ H ₅
	61		-CH ₂ CH(CH ₃) ₂	-C ₆ H ₅
	62		-CH ₂ CH(CH ₃) ₂	-C ₆ H ₅
	63		-CH ₂ CH(CH ₃) ₂	-C ₆ H ₅
10	64		-CH ₂ CH(CH ₃) ₂	-C ₆ H ₅
	65		-CH ₂ CH(CH ₃) ₂	-C ₆ H ₅

TABLE 4 (Cont'd.)

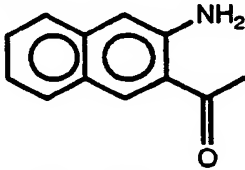
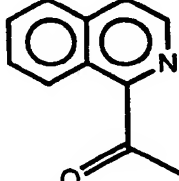
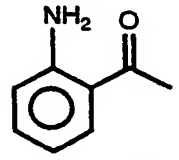
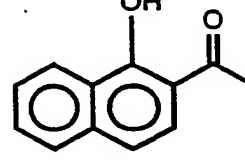
5	Entry No.	R	R ³	R ⁴
	66		$-\text{CH}_2\text{CH}(\text{CH}_3)_2$	$-\text{C}_6\text{H}_5$
	67		$-\text{CH}_2\text{CH}(\text{CH}_3)_2$	$-\text{C}_6\text{H}_5$
	68		$-\text{CH}_2\text{CH}(\text{CH}_3)_2$	$-\text{C}_6\text{H}_5$
	69		$-\text{CH}_2\text{CH}(\text{CH}_3)_2$	$-\text{C}_6\text{H}_5$
10	70	Q	$-\text{CH}_2\text{Ph}$	$-\text{Ph}$
	71	Q	$-\text{CH}_2-\text{C}_6\text{H}_4-\text{F}$	$-\text{Ph}$
	72	Q	$-\text{CH}_2-\text{C}_6\text{H}_4$	$-\text{Ph}$
	73	Q	$-\text{CH}_2-\text{C}_6\text{H}_4-\text{OCH}_3$	$-\text{Ph}$
	74	Q	$-\text{CH}_2-\text{C}_6\text{H}_4-\text{N}$	$-\text{Ph}$

TABLE 4 (Cont'd.)



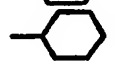







Entry No.	R	R ³	R ⁴
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75	Q	$-\text{CH}_2-$ 	-Ph
76	Q	$-\text{CH}_2\text{CH}=\text{CH}_2$	-Ph
77	Q	$-\text{C}_6\text{H}_5$ 	-Ph
78	Q	$-\text{C}_6\text{H}_4$ 	-Ph
10 79	Q	$-\text{CH}_2\text{CH}_2\text{Ph}$	-Ph
80	Q	$-\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$	-Ph
81	Q	$-\text{CH}_2\text{CH}_2\text{N}(\text{CH}_3)_2$	-Ph
82	Q	$-\text{CH}_2\text{CH}_2-\text{N}$ 	-Ph
83	Q	$-\text{CH}_3$	-Ph
15 84	Q	$-\text{CH}_2\text{CH}_2\text{CH}_2\text{SCH}_3$	-Ph
85	Q	$-\text{CH}_2\text{CH}_2\text{CH}_2\text{S}(\text{O})_2\text{CH}_3$	-Ph
86	Q	$-\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}(\text{CH}_3)_2$	$-\text{C}_6\text{H}_5$ 
87	Q	$-\text{CH}_2\text{CH}_2\text{CH}(\text{CH}_3)_2$	$-\text{CH}_2-\text{C}_6\text{H}_5$ 
88	Q	$-\text{CH}_2\text{CH}_2\text{CH}(\text{CH}_3)_2$	$-\text{CH}_2\text{CH}_2\text{CH}_3$
20 89	Q	$-\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}(\text{CH}_3)_2$	$-\text{CH}_3$
90	Q	$-\text{CH}_2\text{CH}_2\text{CH}(\text{CH}_3)_2$	$-\text{C}_6\text{H}_4-\text{F}$ 
91	Q	$-\text{CH}_2\text{CH}_2\text{CH}(\text{CH}_3)_2$	$-\text{C}_6\text{H}_4$ 
92	Q	$-\text{CH}_2\text{CH}_2\text{CH}(\text{CH}_3)_2$	$-\text{C}_6\text{H}_4-\text{NO}_2$ 
93	Q	$-\text{CH}_2\text{CH}_2\text{CH}(\text{CH}_3)_2$	$-\text{C}_4\text{H}_3\text{S}$ 

TABLE 4 (Cont'd.)

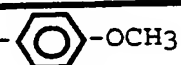
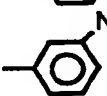
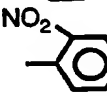
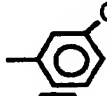



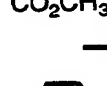






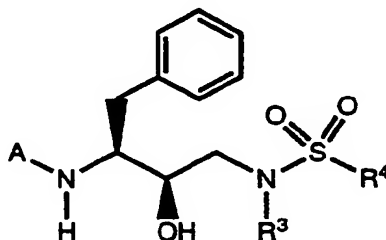
Entry No.	R	R ³	R ⁴
5			
94	Q	-CH ₂ CH ₂ CH(CH ₃) ₂	- 
95	Q	-CH ₂ CH ₂ CH(CH ₃) ₂	- 
96	Q	-CH ₂ CH ₂ CH(CH ₃) ₂	- 
97	Q	-CH ₂ CH ₂ CH(CH ₃) ₂	- 
10	98	-CH ₂ CH ₂ CH(CH ₃) ₂	- 
99	Q	-CH ₂ CH ₂ CH(CH ₃) ₂	- 
100	Q	-CH ₂ CH ₂ CH(CH ₃) ₂	- 
101	Q	-CH ₂ CH ₂ CH(CH ₃) ₂	- 
102	Q	-CH ₂ CH ₂ CH(CH ₃) ₂	- 
15	103	-CH ₂ CH(CH ₃) ₂	- 
104	Q	-CH ₂ CH(CH ₃) ₂	- 
105	Q	-CH ₂ CH(CH ₃) ₂	- 
106	Q	-CH ₂ CH ₂ CH ₃	- 
107	Q	-CH ₂ CH ₂ CH ₂ CH ₃	- 
20	a benzyloxycarbonyl		
	b 2-quinolinylcarbonyl		

TABLE 5

5


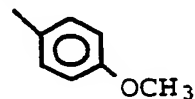
	Entry	A	R ³	R ⁴
10	1	Cbz-Val	<i>i</i> -amyl	-C ₆ H ₅
	2	Cbz-Leu	<i>i</i> -amyl	-C ₆ H ₅
	3	Cbz-Ile	<i>i</i> -amyl	-C ₆ H ₅
	4	Ac-D- <u>homo</u> -Phe	<i>i</i> -Bu	methyl
	5	Qui-Orn(g-Cbz)	-CH ₂ - 	-C ₆ H ₅
15	6	Cbz-Asn	-CH ₂ CH=CH ₂	-C ₆ H ₅
	7	Acetyl-t-BuGly	<i>i</i> -amyl	-C ₆ H ₅
	8	Acetyl-Phe	<i>i</i> -amyl	-C ₆ H ₅
	9	Acetyl-Ile	<i>i</i> -amyl	-C ₆ H ₅
	10	Acetyl-Leu	<i>i</i> -amyl	-C ₆ H ₅
	11	Acetyl-His	<i>i</i> -amyl	-C ₆ H ₅
20	12	Acetyl-Thr	<i>i</i> -amyl	-C ₆ H ₅
	13	Acetyl-NHCH(C(CH ₃) ₂ (SCH ₃))C(O)-	<i>i</i> -amyl	-C ₆ H ₅
	14	Cbz-Asn	<i>i</i> -amyl	-C ₆ H ₅
	15	Cbz-Ala	<i>i</i> -amyl	-C ₆ H ₅
25	16	(N,N-dimethylglyciny)Val	<i>i</i> -amyl	-C ₆ H ₅
	17	(N-methylglyciny)Val	<i>i</i> -amyl	-C ₆ H ₅
	18	(N,N-dimethylglyciny)Ile	<i>i</i> -amyl	-C ₆ H ₅
	19	(N-methylglyciny)Ile	<i>i</i> -amyl	-C ₆ H ₅

TABLE 5 (Cont'd)

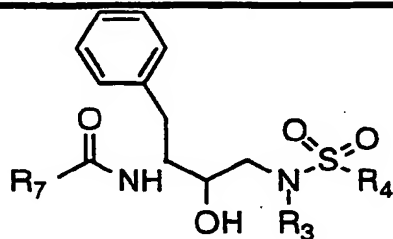
	Entry	A	R ³	R ⁴
5	20	Cbz-Ala	<u>i</u> -amyl	-C ₆ H ₅
	21	Cbz-beta-cyanoAla	<u>i</u> -amyl	-C ₆ H ₅
	22	Cbz-t-BuGly	<u>i</u> -amyl	-C ₆ H ₅
	23	Q-t-BuGly	<u>i</u> -amyl	-C ₆ H ₅
10	24	Q-SCH ₃ Cys	<u>i</u> -amyl	-C ₆ H ₅
	25	Cbz-SCH ₃ Cys	<u>i</u> -amyl	-C ₆ H ₅
	26	Q-Asp	<u>i</u> -amyl	-C ₆ H ₅
	27	Cbz-(NHCH(C(CH ₃) ₂ (SCH ₃))C(O)-	<u>i</u> -amyl	-C ₆ H ₅
	28	Cbz-EtGly	<u>i</u> -amyl	-C ₆ H ₅
15	29	Cbz-PrGly	<u>i</u> -amyl	-C ₆ H ₅
	30	Cbz-Thr	<u>i</u> -amyl	-C ₆ H ₅
	31	Q-Phe	<u>i</u> -amyl	-C ₆ H ₅
	32	Cbz-Phe	<u>i</u> -amyl	-C ₆ H ₅
	33	CH ₂ =CHCH ₂ -O-C(=O)-	<u>i</u> -Butyl	-C ₆ H ₄



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TABLE 5A**Entry**

5

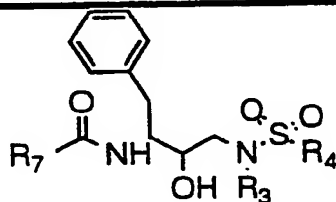
**MASS MEASUREMENT**

	R^3	R^4	R^7	MOL FORM	CALC M+H	FOUND
1				$C_{27}H_{38}N_2O_5S$	503.2661	503.2624
2				$C_{28}H_{40}N_2O_5S$	517.2736	517.2777
3				$C_{29}H_{42}N_2O_5S$	531.2893	531.2916
4				$C_{32}H_{40}N_2O_5S$	565.2736	565.2731
5				$C_{30}H_{35}N_3O_5S$	550.2376	550.2427

TABLE 5A (Cont'd)

Entry

5



MASS MEASUREMENT

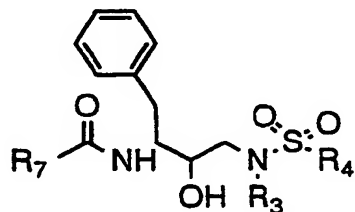
			MOL FORM	CALC	FOUND
6			$C_{30}H_{38}N_2O_5S$	539(M+H)	539
7			$C_{29}H_{36}N_2O_5S$?	?
8			$C_{30}H_{38}N_2O_5S$	539.2580 (M+H)	539.2591

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TABLE 5A (Cont'd)

Entry

5



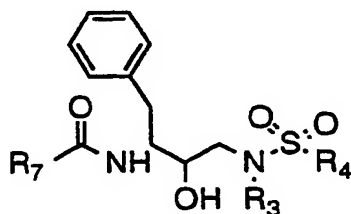
MASS MEASUREMENT

	R ³	R ⁴	R ⁷	MOL FORM	CALC (M+H)	FOUND
9				C ₂₇ H ₃₃ N ₃ O ₅ S	512.2219	512.2271
10				C ₂₈ H ₃₅ N ₃ O ₅ S	526.2376	526.2388
11				C ₂₇ H ₃₃ N ₃ O ₅ S	512.2219	512.2287
12				C ₂₈ H ₃₃ N ₂ O ₅ ClS	545.1877	545.1887
13				C ₃₀ H ₃₈ N ₂ O ₅ S	539.2580	539.2592
14				C ₃₁ H ₄₀ N ₂ O ₅ S	553.2736	553.2714
15				C ₃₀ H ₃₈ N ₂ O ₅ S	539.2580	539.2632
16				C ₃₀ H ₃₈ N ₂ O ₅ S	539 (M+H)	539

TABLE 5A (Cont'd)

Entry

5



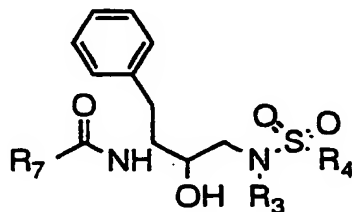
MASS MEASUREMENT

	R ³	R ⁴	R ⁷	MOL FORM	CALC	FOUND
17				C ₂₉ H ₃₆ N ₂ O ₇ S ₂	589.2042 (M+H)	589.2086
18				C ₂₉ H ₃₆ N ₂ O ₇ S ₂	595.2124 (M+Li)	595.2103
19				C ₂₉ H ₃₆ N ₂ O ₇ S ₂	595.2124 (M+Li)	595.2191
20				C ₃₀ H ₃₈ N ₂ O ₇ S ₂	609.2281 (M+Li)	609.2313
21				C ₃₀ H ₃₈ N ₂ O ₇ S ₂	603.2199 (M+H)	603.2247
22				C ₃₀ H ₃₈ N ₂ O ₇ S ₂	603.2199 (M+H)	603.2266

TABLE 5A (Cont'd)

Entry

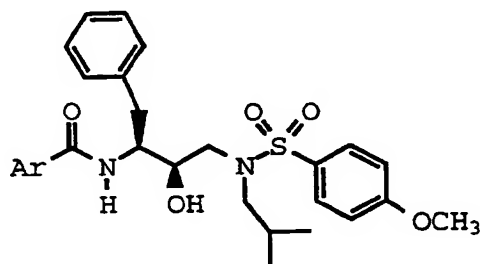
5



EXACT MASS MEASUREMENT

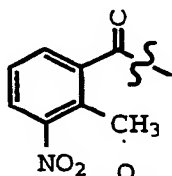
	R ³	R ⁴	R ⁷	MOL FORM	CALC (M+H)	FOUND
23						
24				C ₂₇ H ₃₂ N ₂ O ₄ S	481.2161	481.2213
25				C ₂₈ H ₃₅ N ₂ O ₅ S	511.2267	511.2319
26				C ₂₉ H ₃₆ N ₂ O ₅ S	525.2423	525.2469
27				C ₂₉ H ₃₆ N ₂ O ₅ S	525.2428	525.2464
28				C ₂₉ H ₃₆ N ₂ O ₅ S	525.2423	525.2432
29				C ₂₉ H ₃₆ N ₂ O ₆ S	541.2372	541.2332
30				C ₂₉ H ₃₆ N ₂ O ₆ S	541.2372	541.2355
31				C ₂₉ H ₃₆ N ₂ O ₆ S	541.2372	541.2329

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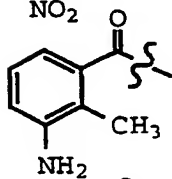
TABLE 5B

5

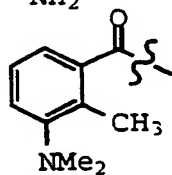
Entry	A	Molecular Formula	Mass Spectrum
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C₂₉H₃₅N₃O₇S

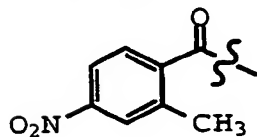
576 (M+Li)

C₂₉H₃₇N₃O₅S

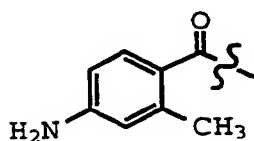
540 (M+H)

C₃₁H₄₁N₃O₅S

568 (M+H)

C₂₉H₃₅N₃O₇S

570 (M+H)

C₂₉H₃₇N₃O₅S

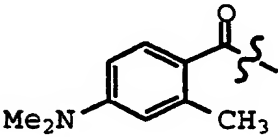
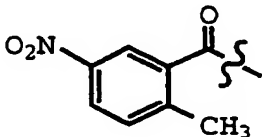
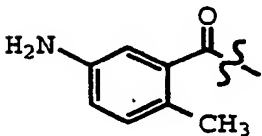
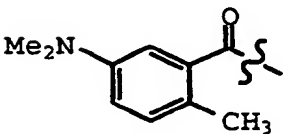
540 (M+H)

10

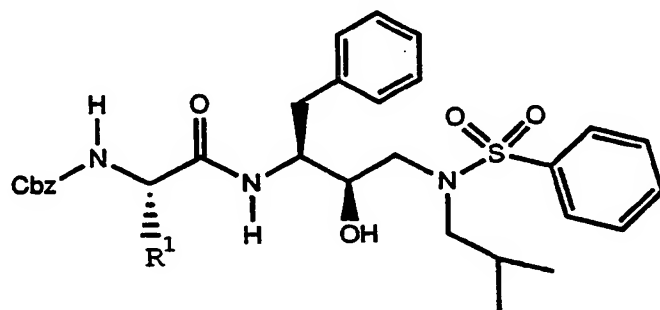
175

TABLE 5B (contd.)

5

<u>Entry</u>	<u>A</u>	<u>Molecular Formula</u>	<u>Mass Spectrum</u>
		$C_{31}H_{41}N_3O_5S$	568 (M+H)
		$C_{29}H_{35}N_3O_7S$	570 (M+H)
		$C_{29}H_{37}N_3O_5S$	546 (M+Li)
		$C_{31}H_{41}N_3O_5S$	574 (M+Li)

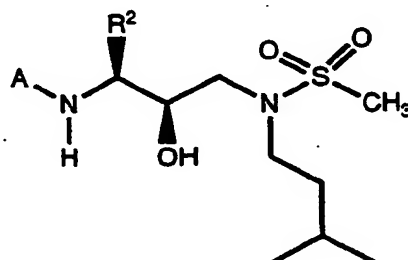
176

TABLE 6

5

Entry		R ¹
10	1	CH ₂ SO ₂ CH ₃
	2	(R) -CH(OH)CH ₃
	3	CH(CH ₃) ₂
	4	(R, S)CH ₂ SOCH ₃
	5	CH ₂ SO ₂ NH ₂
	6	CH ₂ SCH ₃
15	7	CH ₂ CH(CH ₃) ₂
	8	CH ₂ CH ₂ C(O)NH ₂
	9	(S) -CH(OH)CH ₃
	10	-CH ₂ C≡C-H

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TABLE 7

5

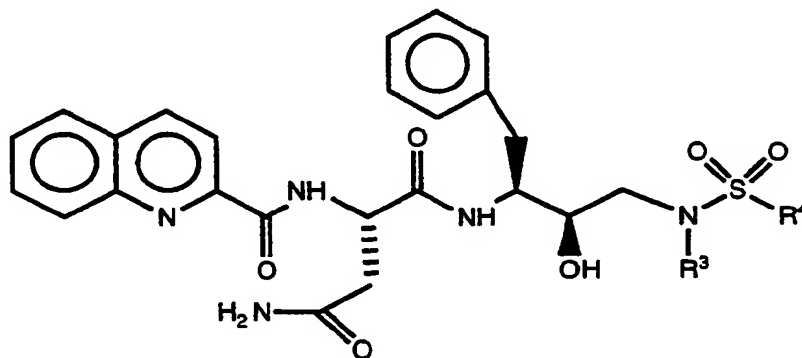
	Entry	R ²	A
	1	n-Bu	Cbz-Asn
10	2	cyclohexylmethyl	Cbz-Asn
	3	n-Bu	Boc
	4	n-Bu	Cbz
	5	C ₆ H ₅ CH ₂	Boc
	6	P-F-C ₆ H ₅ CH ₂	Cbz
15	7	C ₆ H ₅ CH ₂	benzoyl
	8	cyclohexylmethyl	Cbz
	9	n-Bu	Q-Asn
	10	cyclohexylmethyl	Q-Asn
	11	C ₆ H ₅ CH ₂	Cbz-Ile
20	12	C ₆ H ₅ CH ₂	Q-Ile
	13	P-F-C ₆ H ₅ CH ₂	Cbz-t-BuGly
	14	C ₆ H ₅ CH ₂	Q-t-BuGly
	15	C ₆ H ₅ CH ₂	Cbz-Val
	16	C ₆ H ₅ CH ₂	Q-Val
25	17	2-naphthylmethyl	Cbz-Asn
	18	2-naphthylmethyl	Q-Asn
	19	2-naphthylmethyl	Cbz
	20	n-Bu	Cbz-Val
	21	n-Bu	Q-Val
30	22	n-Bu	Q-Ile
	23	n-Bu	Cbz-t-BuGly

TABLE 7 (Cont'd)

	Entry	R ²	A
5	24	n-Bu	Q-t-BuGly
	25	p-F (C ₆ H ₄)CH ₂	Q-Asn
	26	p-F (C ₆ H ₄)CH ₂	Cbz
	27	p-F (C ₆ H ₄)CH ₂	Cbz-Asn
10	28	C ₆ H ₅ CH ₂	Cbz-propargylglycine
	29	C ₆ H ₅ CH ₂	Q-propargylglycine
	30	C ₆ H ₅ CH ₂	
	acetylpropargylglycine		

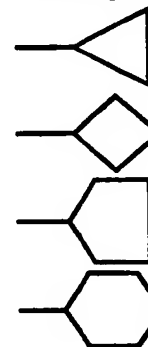
15

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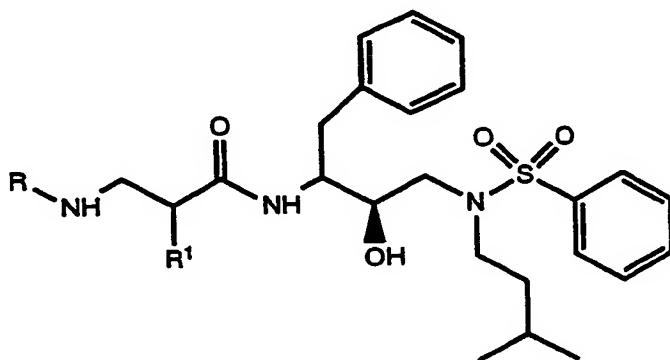
TABLE 8

5

Entry	R ³	R ⁴
10	1	-CH ₂ CH(CH ₃) ₂
	2	-CH ₂ CH ₂ CH(CH ₃) ₂
	3	-CH ₂ CH ₂ CH(CH ₃) ₂
	4	-CH ₂ CH ₂ CH(CH ₃) ₂
	5	-CH ₂ CH ₂ CH(CH ₃) ₂



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TABLE 9

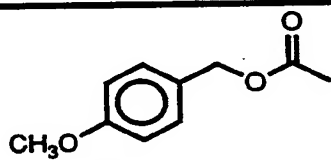
5

Entry

R

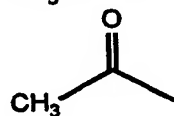
R¹

1

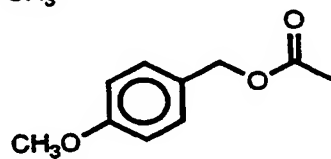
-CH₃

10

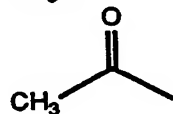
2

-CH₃

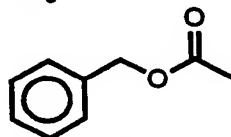
3

-CH(CH₃)₂

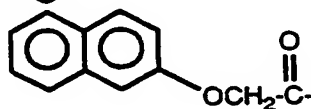
4

-CH(CH₃)₂

5

-C(CH₃)₃

6

-CH₃

15

7

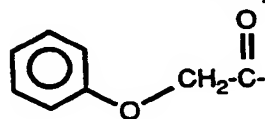
-CH₃

Table 9 (Cont'd)

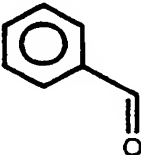
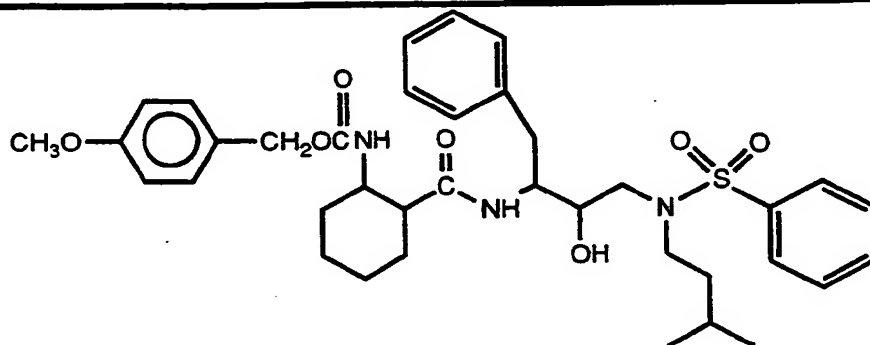
5	Entry	R	R ¹
	8	$\text{HO}_2\text{CCH}_2\text{CH}_2\text{C}(=\text{O})-$	-CH ₃
	9		-CH ₃
10	10	$\text{CH}_3\text{NH-C}(=\text{O})-$	-CH ₃
	11	$(\text{CH}_3)_2\text{CH-C}(=\text{O})-$	-CH ₃
15	12	$\text{CH}_3\text{OCH}_2\text{C}(=\text{O})-$	-CH ₃
	13	$(\text{CH}_3)_2\text{NCH}_2\text{C}(=\text{O})-$	-CH ₃
	14	$\text{CH}_3\text{CH}(\text{OH})\text{C}(=\text{O})-$	-CH ₃

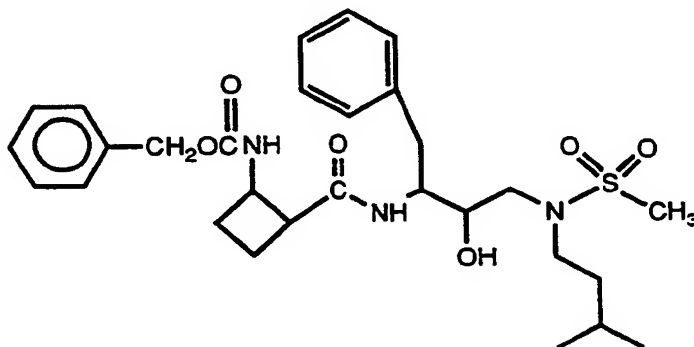
TABLE 9 (Cont'd)

5 Entry

15

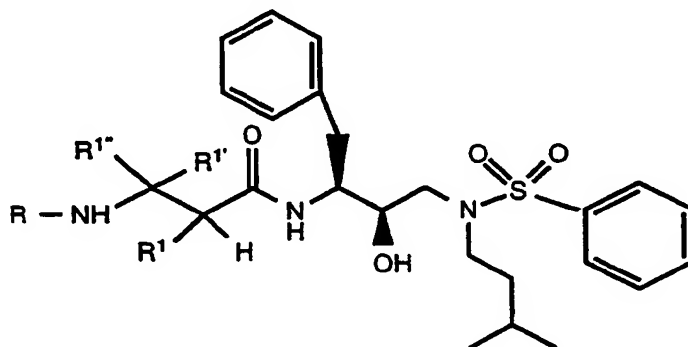


16



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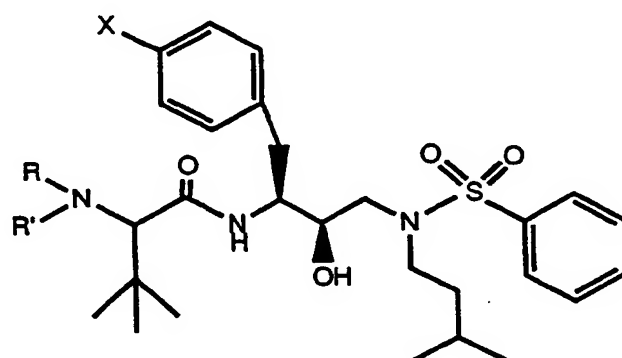
TABLE 10



5

Entry	R ¹	R ^{1'}	R ^{1''}	R
1	H	H	H	
2	H	H	H	
3	H	CH ₃	H	
4	H	CH ₃	CH ₃	
5	H	H	CO ₂ CH ₃	
6	H	H	H	
7	H	H	H	
8	H	H	CONH ₂	Cbz
9	H	H	CONH ₂	2-quinolinylcarbonyl

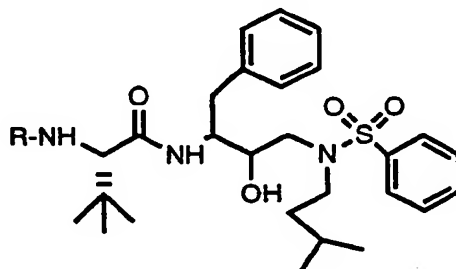
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TABLE 11

5

Entry		R	R'	X
10	1	R=H	R'=H	X=H
	2	R=Me	R'=Me	X=H
	3	R=H	R'=Me	X=H
	4	R=Me	R'=Me	X=F
	5	R=H	R'=Me	X=F
15	6	R=Cbz	R'=Me	X=H
	7	R=H	R'=Bz	X=H
	8	R+R'=pyrrole		X=H

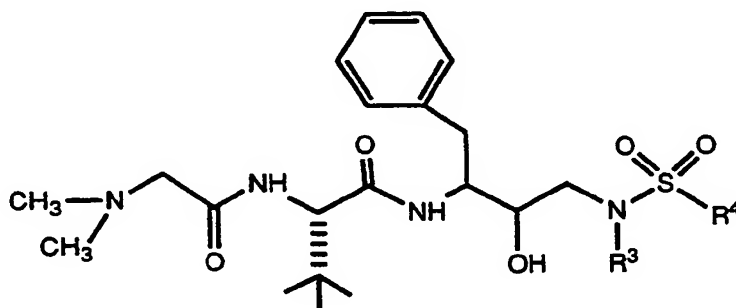
20

TABLE 12

5

Entry	Acyl Group (R)
1	benzyloxycarbonyl
10	<u>tert</u> -butoxycarbonyl
3	acetyl
4	2-quinoylcarbonyl
5	phenoxyacetyl
6	benzoyl
15	methyloxaloyl
8	pivaloyl
9	trifluoracetyl
10	bromoacetyl
11	hydroxyacetyl
20	morpholinylacetyl
13	N,N-dimethylaminoacetyl
14	N-benzylaminoacetyl
15	N-phenylaminoacetyl
16	N-benzyl-N-methylaminoacetyl
25	N-methyl-N-(2-hydroxyethyl)aminoacetyl
18	N-methylcarbamoyl
19	3-methylbutyryl
20	N-isobutylcarbamoyl
21	succinoyl (3-carboxypropionyl)
30	carbamoyl
23	N-(2-indanyl)aminoacetyl

TABLE 13



5

Entry	R ³	R ⁴
10	1 -CH ₃	-n-Butyl
	2 -i-Butyl	-CH ₃
	3 -i-Butyl	-n-Butyl
	4 -i-Propyl	-n-Butyl
	5 -C ₆ H ₅	-n-Butyl
15	6 -CH ₂ -	-n-Butyl
	7 -CH ₂ -	-n-Butyl
	8 -	-n-Butyl
	9 -i-Butyl	-n-Propyl
20	10 -i-Butyl	-CH ₂ CH(CH ₃) ₂
	11 -(R)-CH(CH ₃)-	-n-Butyl
	12 -CH ₂ -	-i-Propyl
	13 -CH ₂ -	-CH ₂ CH ₂ CH(CH ₃) ₂
	14 i-Butyl	-CH ₂ CH ₃
	15 i-Butyl	-CH(CH ₃) ₂
	16 i-Butyl	-

TABLE 13 (cont.)

Entry	R ³	R ⁴
5		
17	$-\text{CH}_2-\text{C}_6\text{H}_{11}$	$-(\text{CH}_2)_2\text{CH}(\text{CH}_3)_2$
18	$(\text{CH}_2)_2\text{CH}(\text{CH}_3)_2$	$-\text{CH}(\text{CH}_3)_2$
19	i-Butyl	$-\text{CH}(\text{CH}_3)_2$
20	i-Butyl	$-\text{C}(\text{CH}_3)_3$
10	21	$-\text{CH}_2-\text{C}_{10}\text{H}_7$
22	$-(\text{CH}_2)_2\text{CH}(\text{CH}_3)_2$	$-\text{C}(\text{CH}_3)_3$
23	$-\text{CH}_2\text{C}_6\text{H}_5$	$-\text{C}(\text{CH}_3)_3$
24	$-(\text{CH}_2)_2\text{C}_6\text{H}_5$	$-\text{C}(\text{CH}_3)_3$
25	n-Butyl	$-\text{C}(\text{CH}_3)_3$
15	26	n-Pentyl
27	n-Hexyl	$-\text{C}(\text{CH}_3)_3$
28	$-\text{CH}_2-\text{C}_6\text{H}_4$	$-\text{C}(\text{CH}_3)_3$
29	$-\text{CH}_2\text{C}(\text{CH}_3)_3$	$-\text{C}(\text{CH}_3)_3$
30	$-\text{CH}_2\text{CH}_2-\text{N} \begin{array}{c} \diagup \text{O} \diagdown \end{array}$	$-\text{C}(\text{CH}_3)_3$
20	31	$-\text{CH}_2\text{C}_6\text{H}_5\text{OCH}_3$ (para)
32	$-\text{CH}_2-\text{C}_5\text{H}_4\text{N}$	$-\text{C}(\text{CH}_3)_3$
33	$-\text{CH}_2-\text{C}_5\text{H}_4\text{N}$	$-\text{C}(\text{CH}_3)_3$
34	$-(\text{CH}_2)_2\text{C}(\text{CH}_3)_3$	$-\text{C}(\text{CH}_3)_3$
35	$-(\text{CH}_2)_4\text{OH}$	$-\text{C}(\text{CH}_3)_3$
25	36	$-\text{CH}_2-\text{C}_6\text{H}_4-\text{F}$

TABLE 13 (cont.)

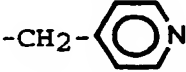
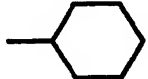
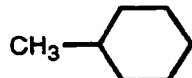
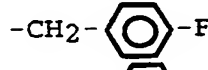
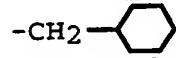

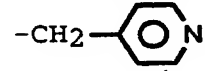
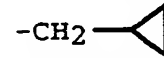
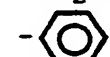

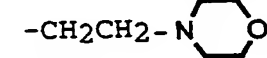
5	Entry	R ³	R ⁴
	37		-C(CH ₃) ₃
	38	-CH ₂ CH(CH ₃) ₂	-C ₆ H ₅
	39	i-amyl	-CH ₂ C(CH ₃) ₃
	40		-CH ₂ C(CH ₃) ₃
	41		-CH ₂ C(CH ₃) ₃
10	42	i-butyl	-CH ₂ C(CH ₃) ₃
	43	-CH ₂ Ph	-Ph
	44		-Ph
	45		-Ph
15	46		-Ph
	47		-Ph
	48		-Ph
	49	-CH ₂ CH=CH ₂	-Ph
20	50		-Ph
	51		-Ph
	52	-CH ₂ CH ₂ Ph	-Ph
	53	-CH ₂ CH ₂ CH ₂ CH ₂ OH	-Ph
	54	-CH ₂ CH ₂ N(CH ₃) ₂	-Ph
	55		-Ph
	56	-CH ₃	-Ph
25			

TABLE 13 (cont.)





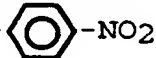


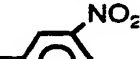
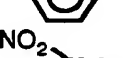

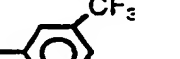

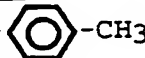
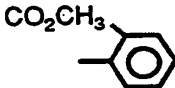


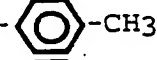
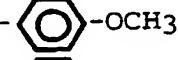

	Entry	R ³	R ⁴
5	57	-CH ₂ CH ₂ CH ₂ SCH ₃	-Ph
	58	-CH ₂ CH ₂ CH ₂ S(O) ₂ CH ₃	-Ph
	59	-CH ₂ CH ₂ CH(CH ₃) ₂	- 
	60	-CH ₂ CH ₂ CH(CH ₃) ₂	-CH ₂ - 
10	61	-CH ₂ CH ₂ CH(CH ₃) ₂	-CH ₂ CH ₂ CH ₃
	62	-CH ₂ CH ₂ CH(CH ₃) ₂	-CH ₃
	63	-CH ₂ CH ₂ CH(CH ₃) ₂	- 
	64	-CH ₂ CH ₂ CH(CH ₃) ₂	- 
15	65	-CH ₂ CH ₂ CH(CH ₃) ₂	- 
	66	-CH ₂ CH ₂ CH(CH ₃) ₂	- 
	67	-CH ₂ CH ₂ CH(CH ₃) ₂	- 
	68	-CH ₂ CH ₂ CH(CH ₃) ₂	- 
20	69	-CH ₂ CH ₂ CH(CH ₃) ₂	- 
	70	-CH ₂ CH ₂ CH(CH ₃) ₂	- 
	71	-CH ₂ CH ₂ CH(CH ₃) ₂	- 
	72	-CH ₂ CH ₂ CH(CH ₃) ₂	- 

TABLE 13 (cont.)

	Entry	R ³	R ⁴
5	73	-CH ₂ CH ₂ CH(CH ₃) ₂	- 
	74	-CH ₂ CH ₂ CH(CH ₃) ₂	- 
	75	-CH ₂ CH(CH ₃) ₂	- 
	76	-CH ₂ CH(CH ₃) ₂	- 
	10	77	-CH ₂ CH(CH ₃) ₂
78		-CH ₂ CH(CH ₃) ₂	- 
79		-CH ₂ CH ₂ CH ₃	- 
80		-CH ₂ CH ₂ CH ₂ CH ₃	- 

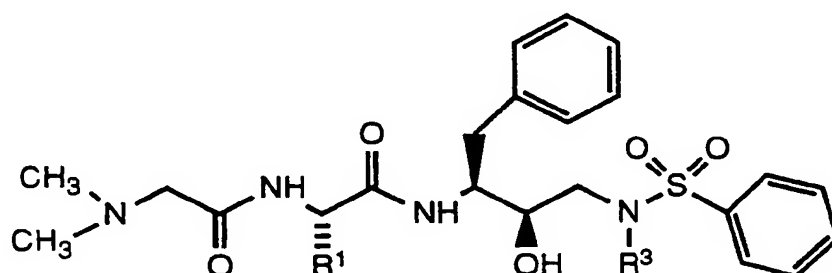
15

a benzyloxycarbonyl

b 2-quinolinylcarbonyl

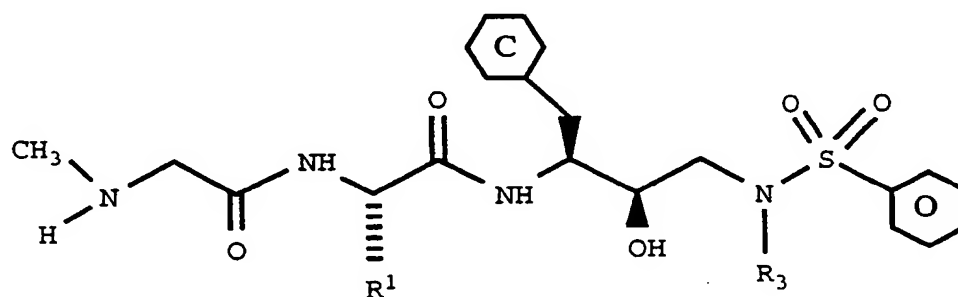
20

191

Table 14

5

Entry	R ¹	R ³
1	C(CH ₃) ₃	CH ₂ CH ₂ CH(CH ₃) ₂
2	CH ₂ C≡CH	CH ₂ CH ₂ CH(CH ₃) ₂
3	C(CH ₃) ₂ (SCH ₃)	CH ₂ CH ₂ CH(CH ₃) ₂
4	C(CH ₃) ₂ (S[O]CH ₃)	CH ₂ CH ₂ CH(CH ₃) ₂
5	C(CH ₃) ₂ (S[O] ₂ CH ₃)	CH ₂ CH ₂ CH(CH ₃) ₂
6	C(CH ₃) ₃	CH ₂ CH(CH ₃) ₂
7	C(CH ₃) ₃	cyclohexyl
8	CH(CH ₃) ₂	CH ₂ CH(CH ₃) ₂
9	CH(CH ₂ CH ₃)(CH ₃)	CH ₂ CH(CH ₃) ₂

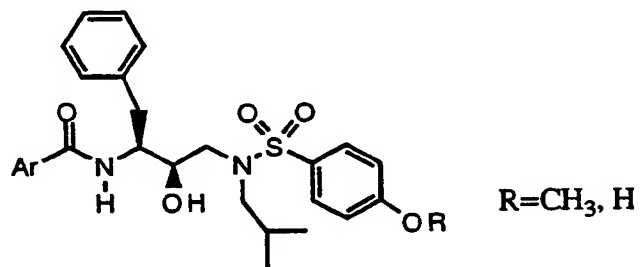
Table 14A

25

Entry	R ¹	R ³
1	C(CH ₃)SCH ₃	CH ₂ CH ₂ CH(CH ₃) ₂

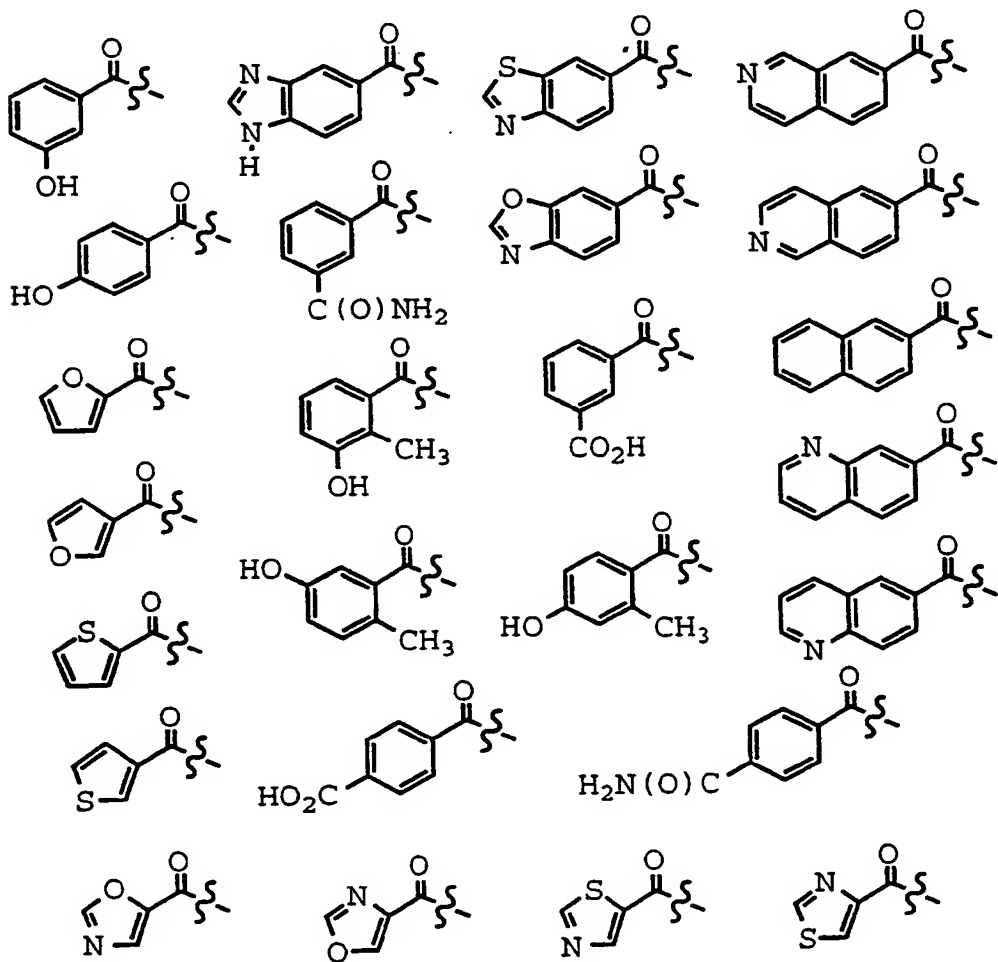
192

Table 15



5

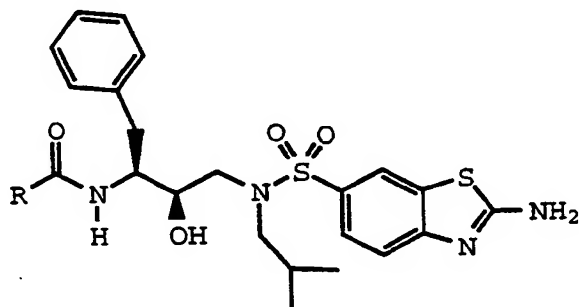
Ar



10

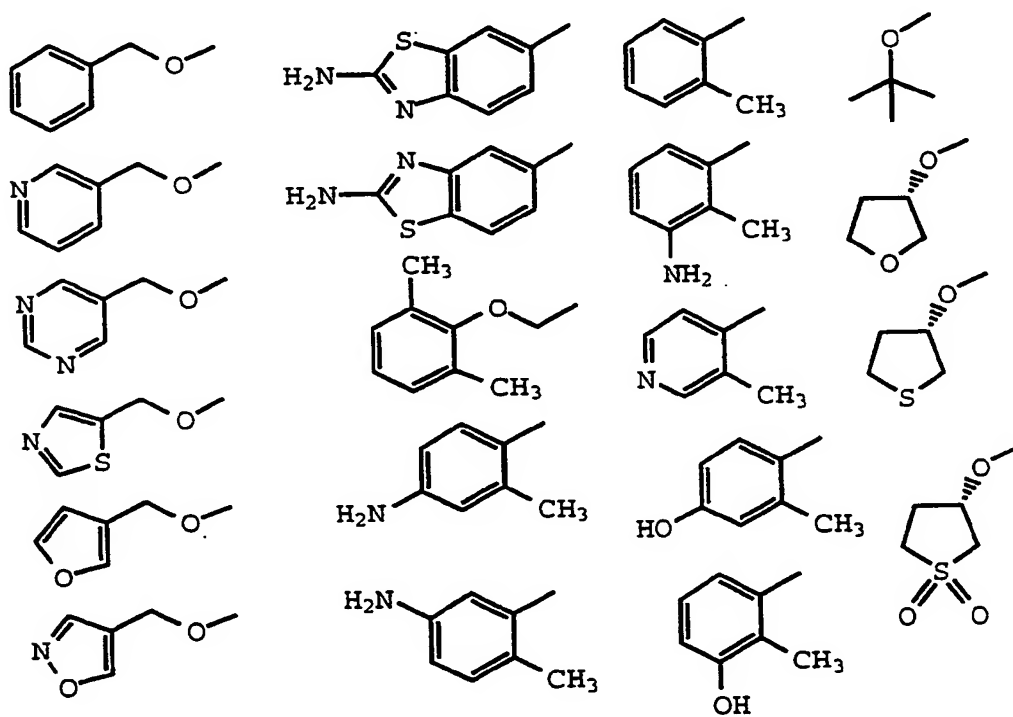
194

Table 16A



5

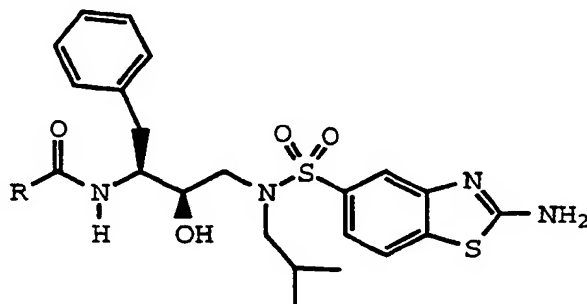
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10

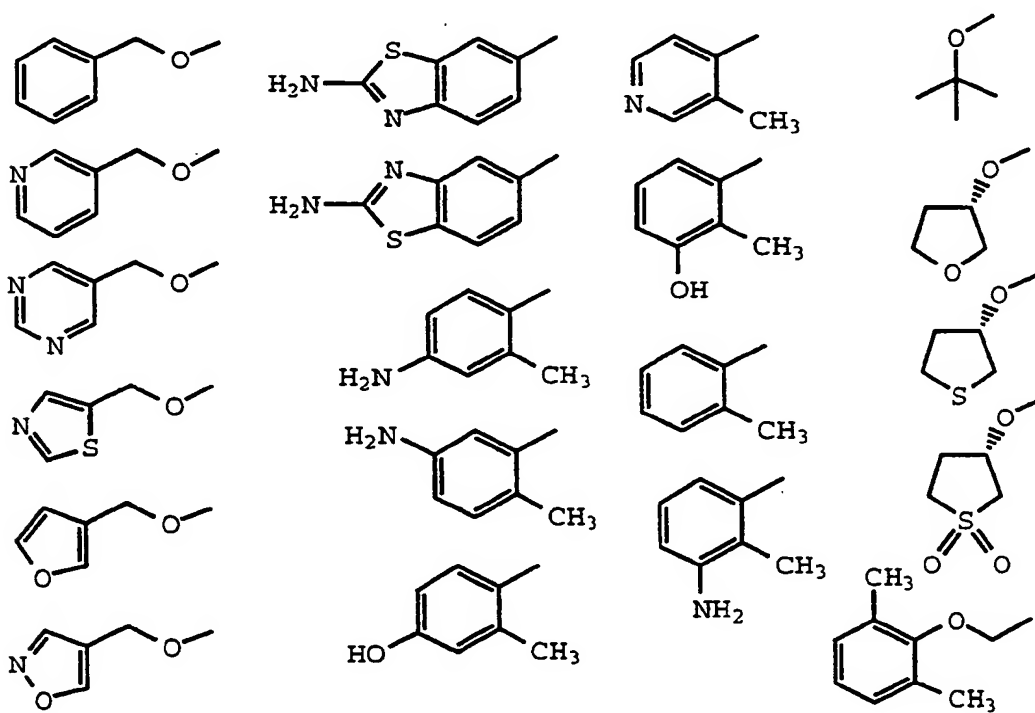
195

Table 16B



5

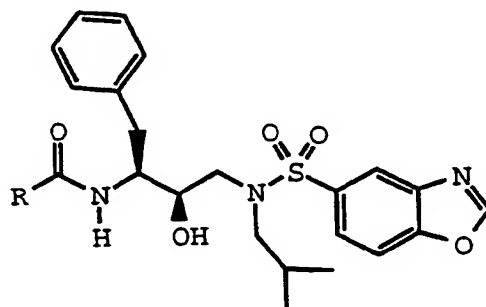
R



10

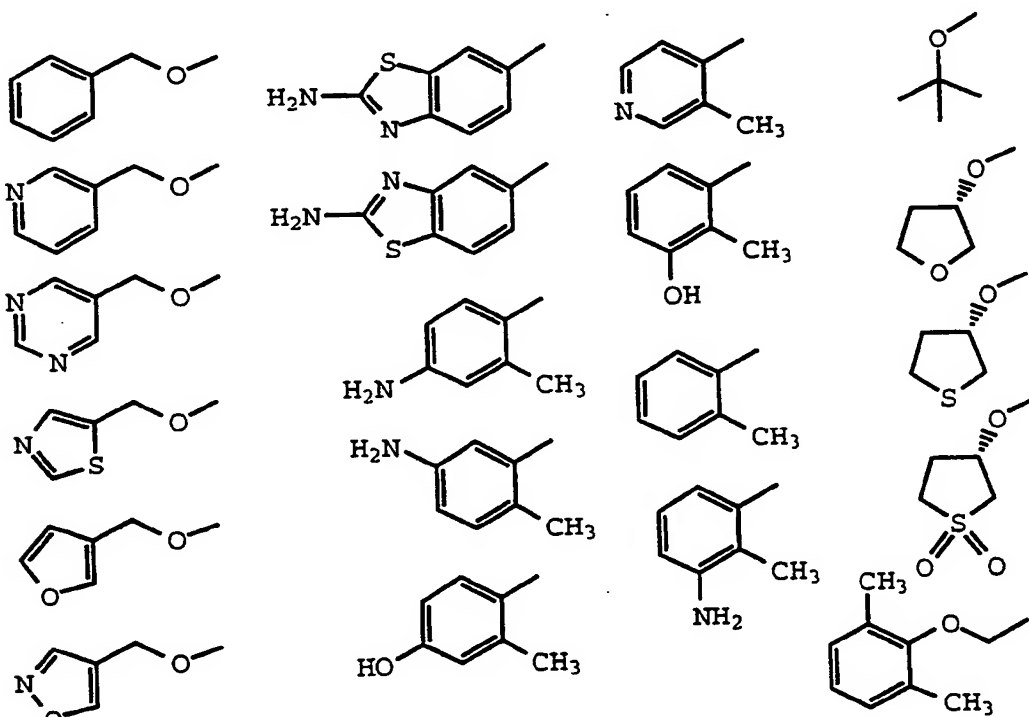
196

Table 16C



5

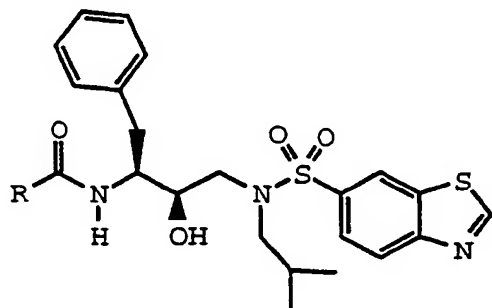
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10

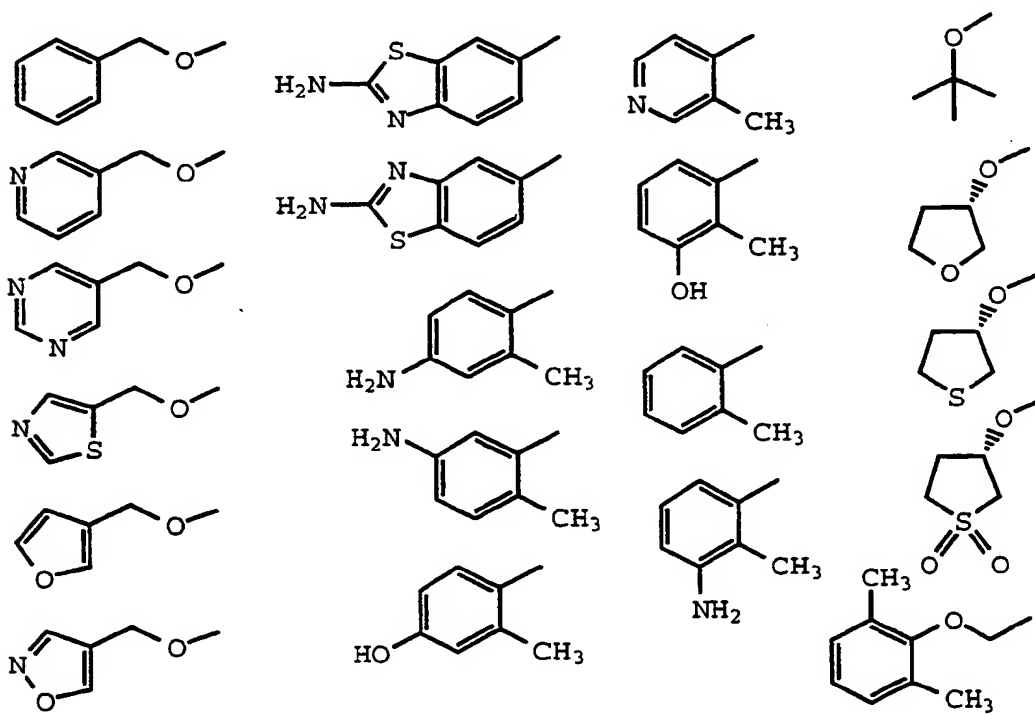
197

Table 16D



5

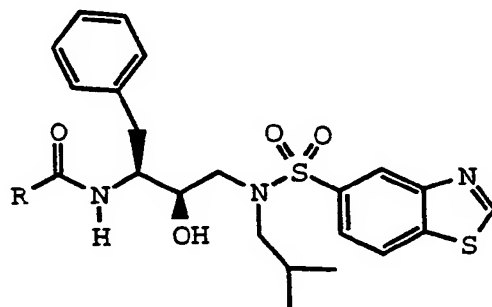
R



10

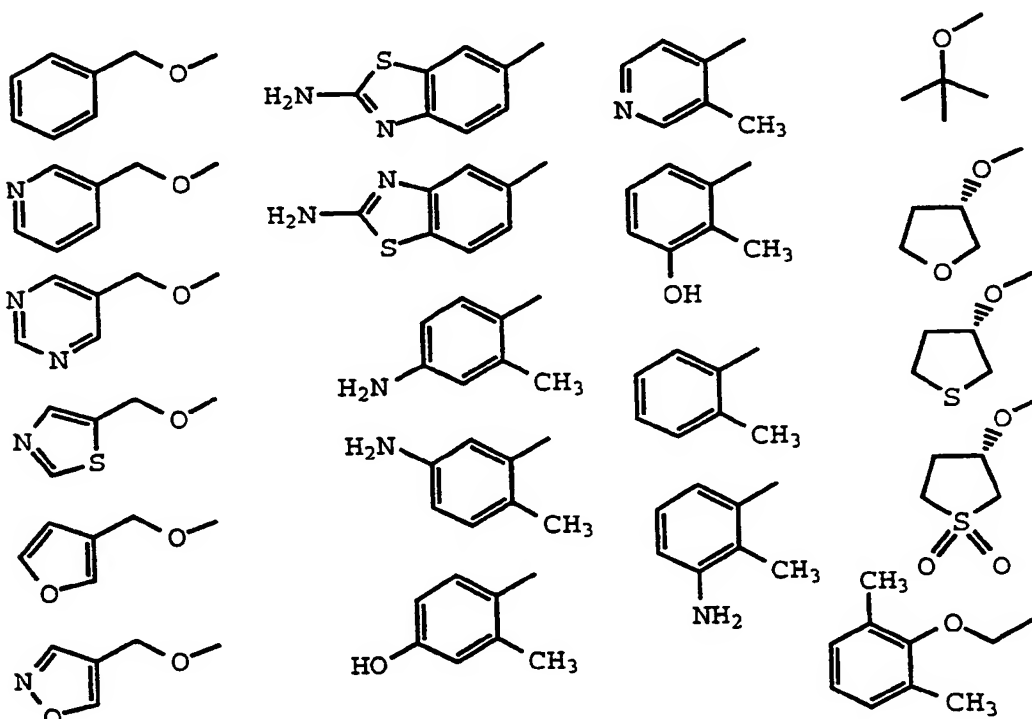
198

Table 16E



5

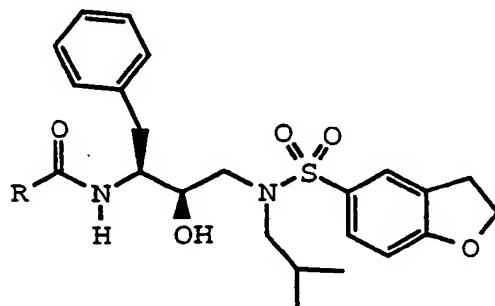
R



10

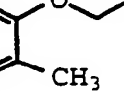
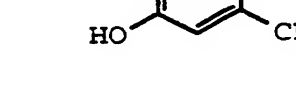
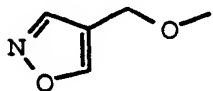
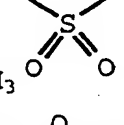
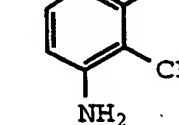
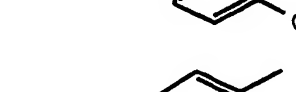
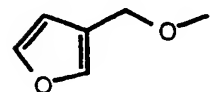
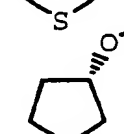
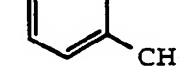
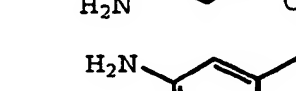
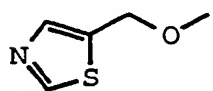
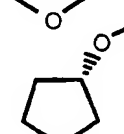
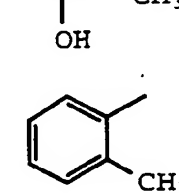
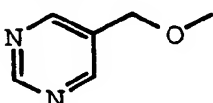
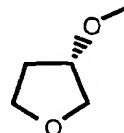
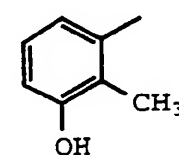
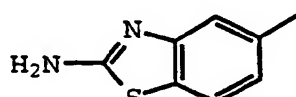
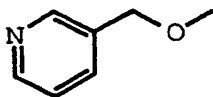
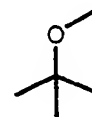
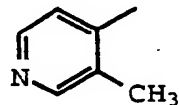
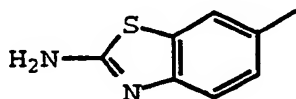
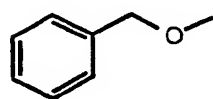
199

Table 16F



5

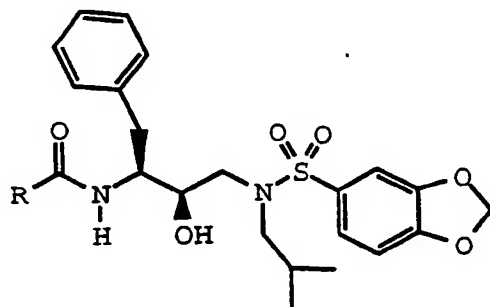
R



10

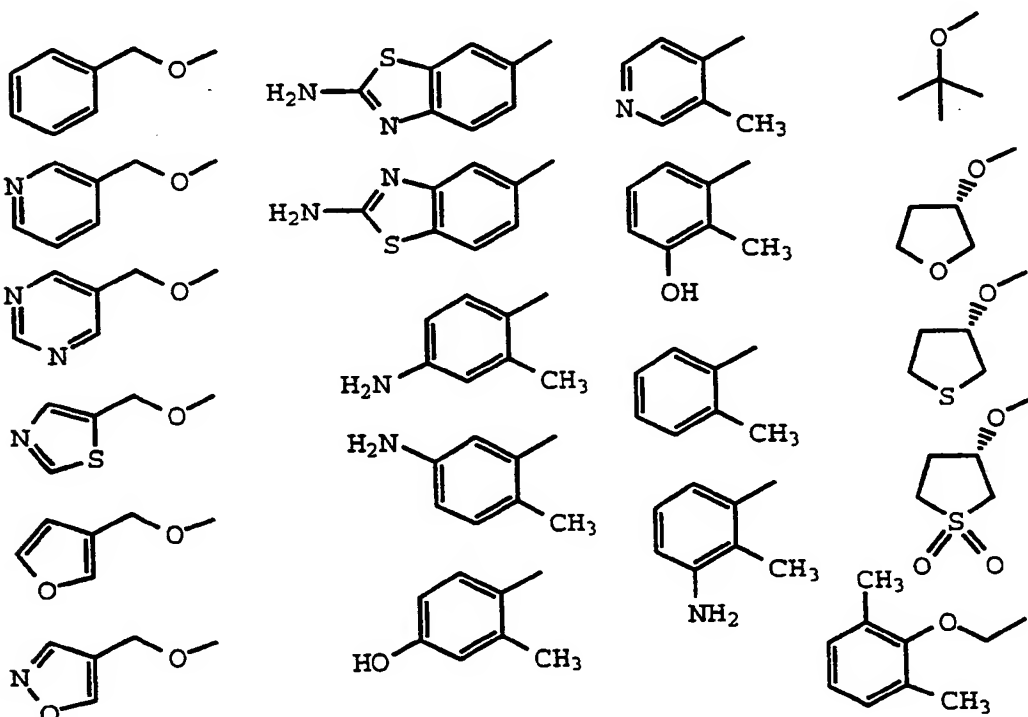
200

Table 16G



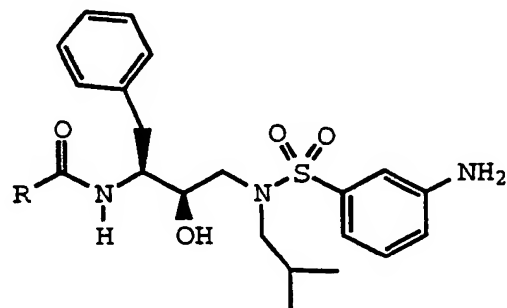
5

R



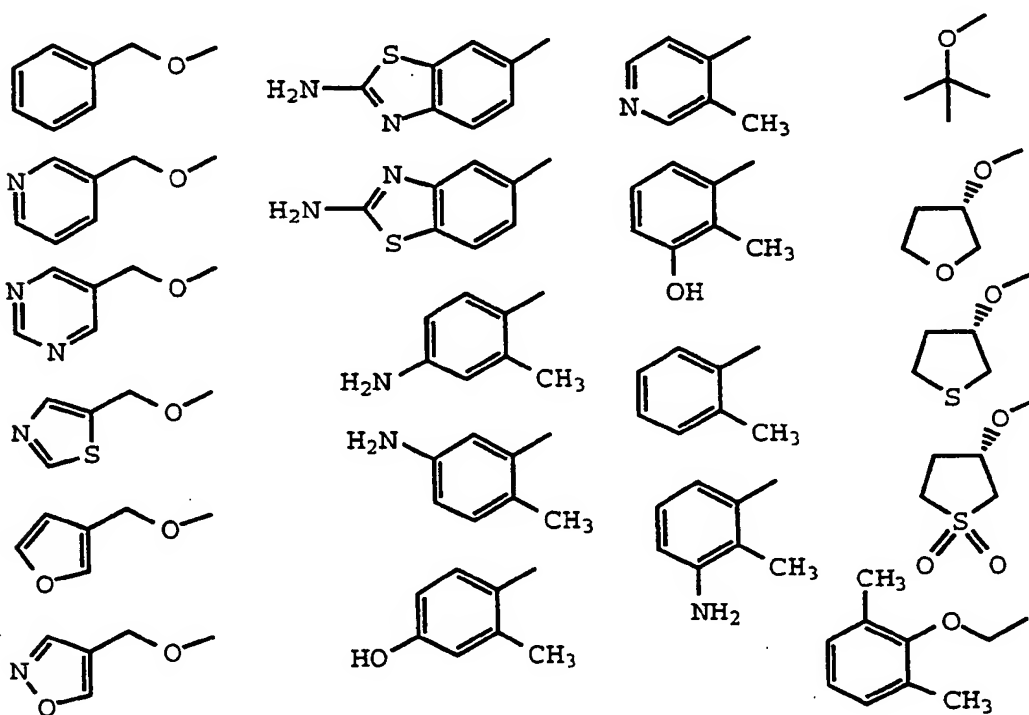
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201

Table 16H

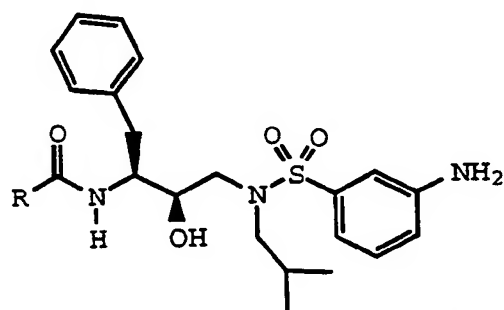
5

R

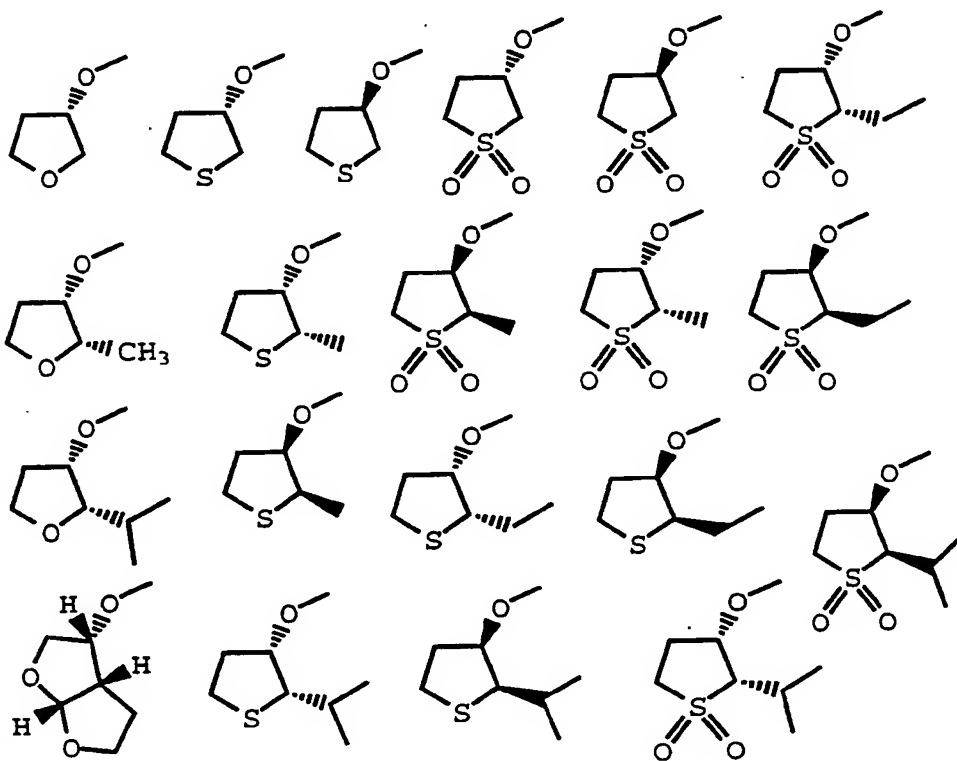


10

202

Table 16I

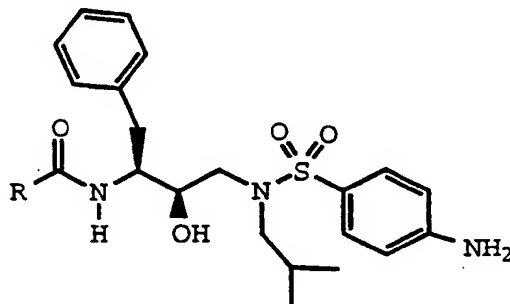
5

R

10

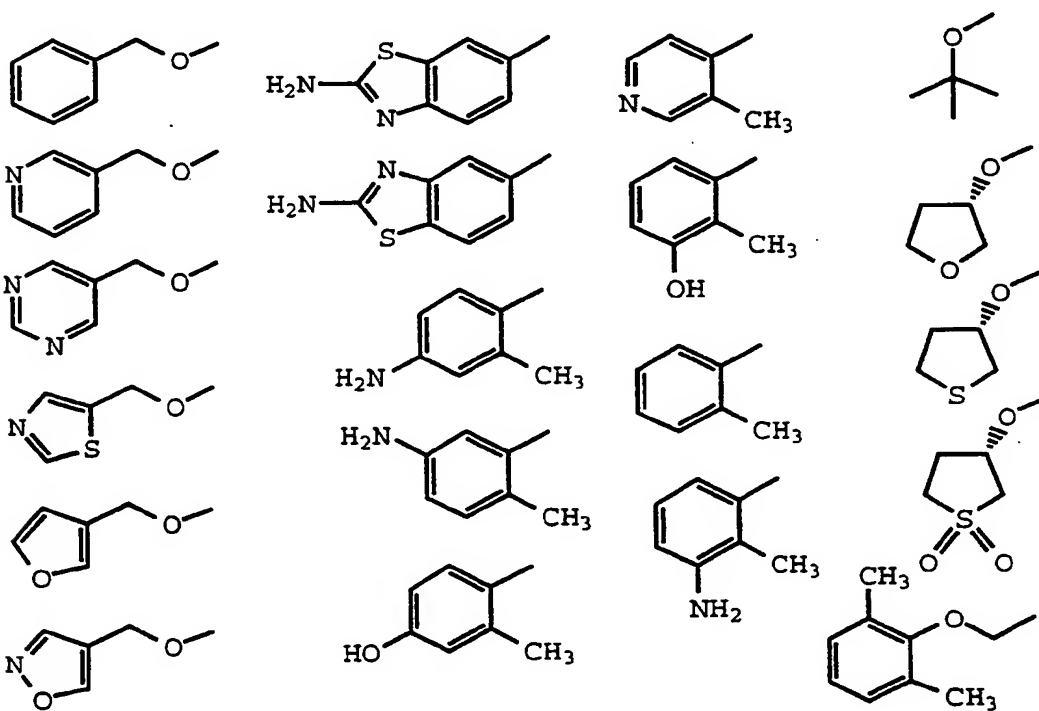
203

Table 16J



5

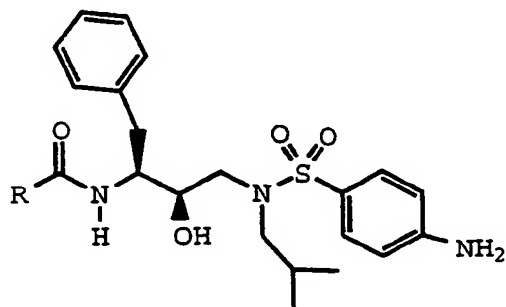
R



10

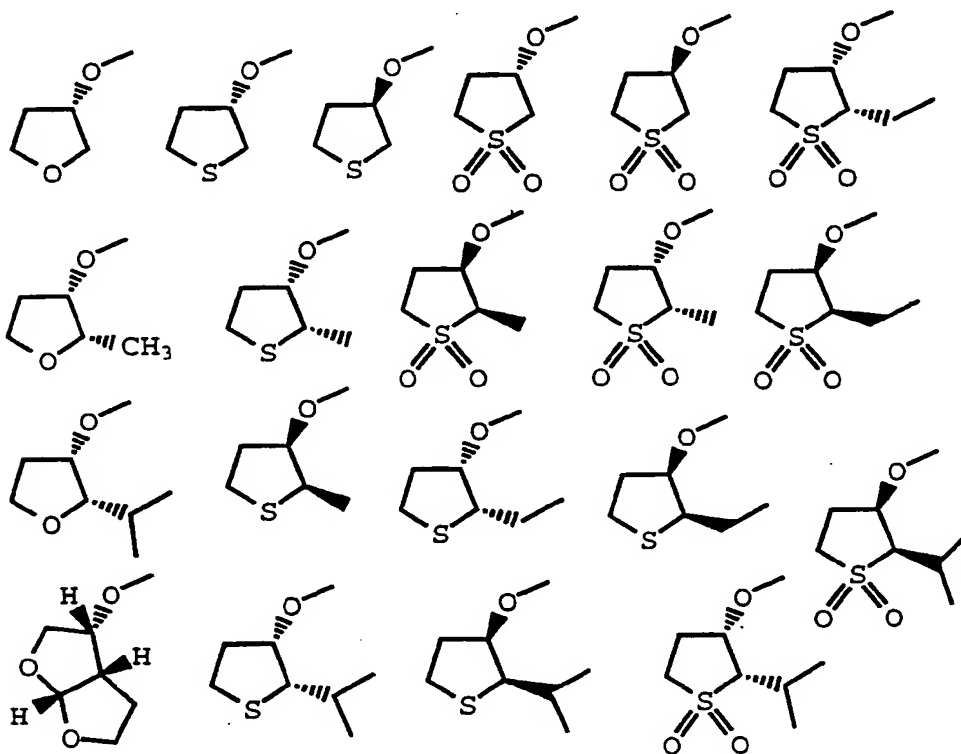
204

Table 16K



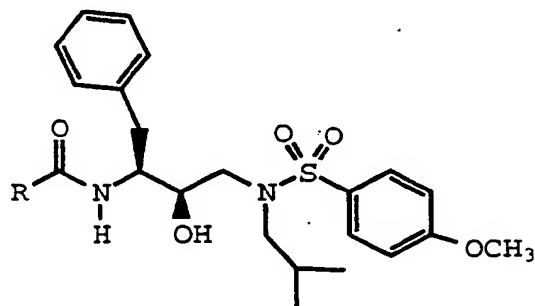
5

R

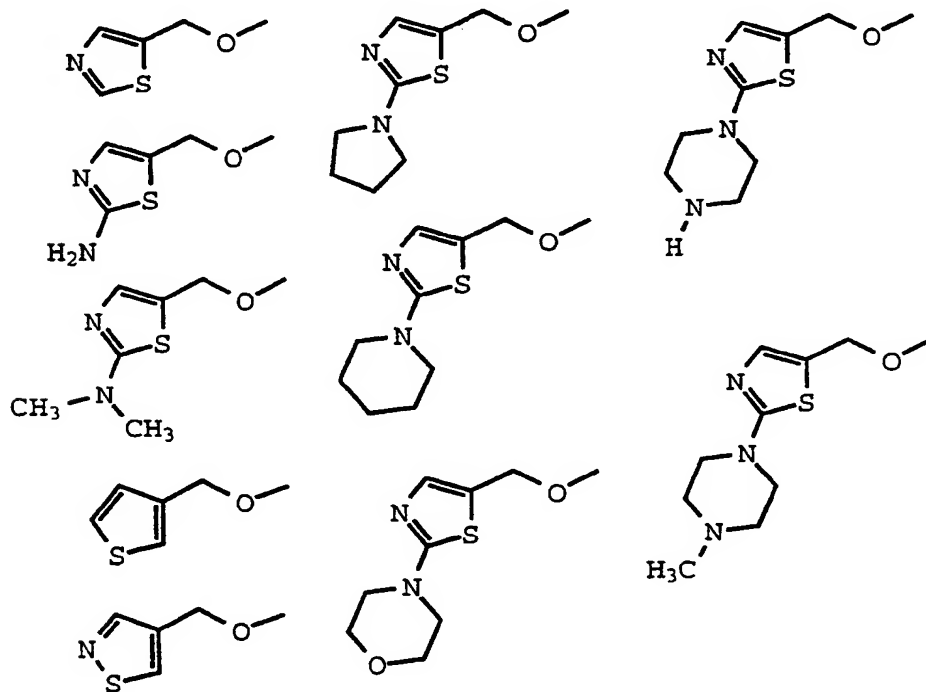


10

205

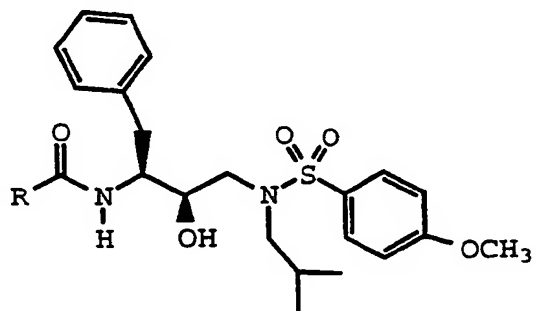
Table 16L

5

R

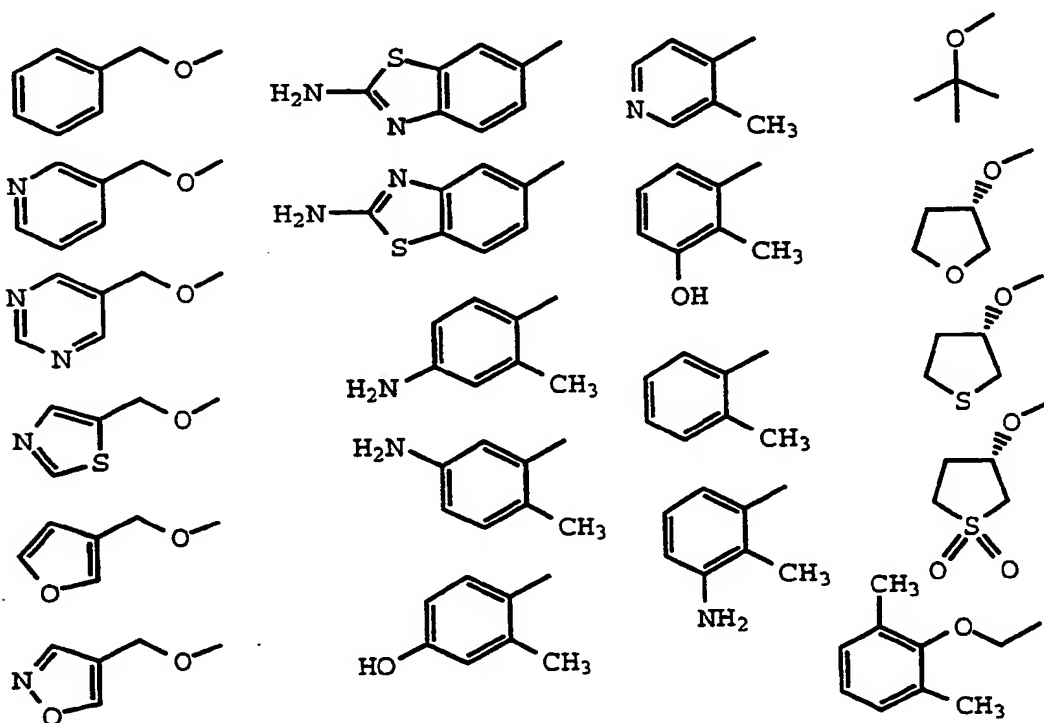
206

Table 16M



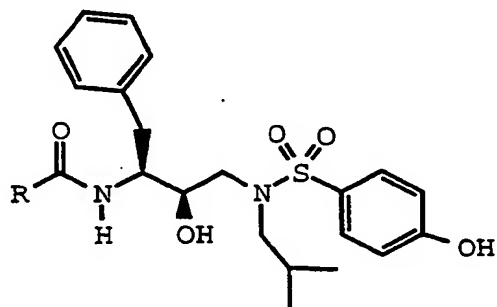
5

R



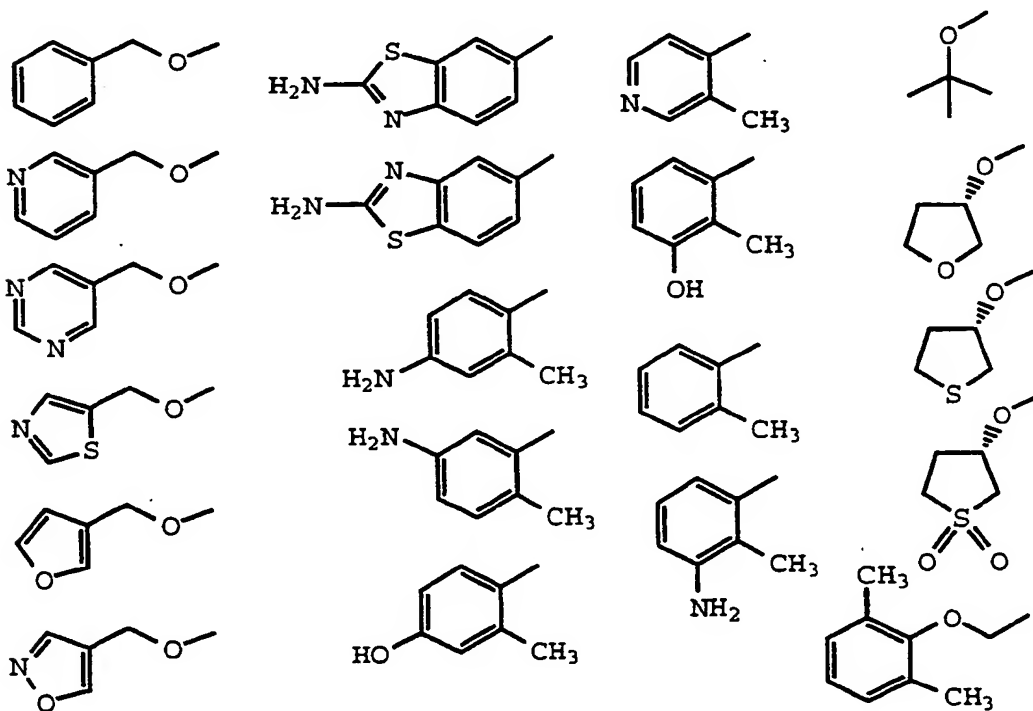
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Table 16N



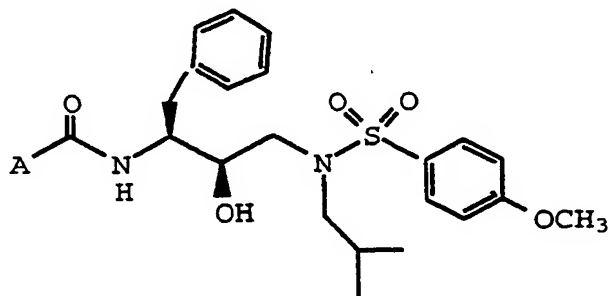
5

R

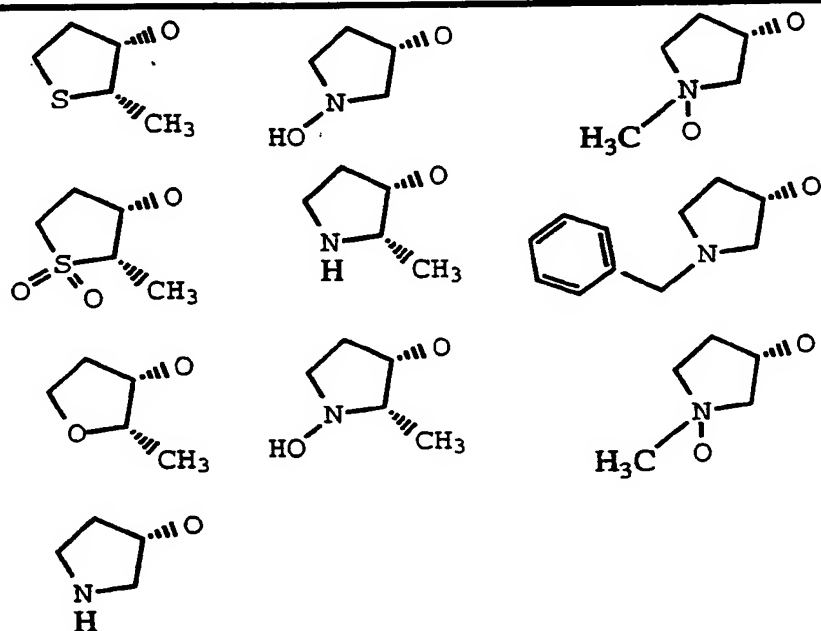


10

208

TABLE 17

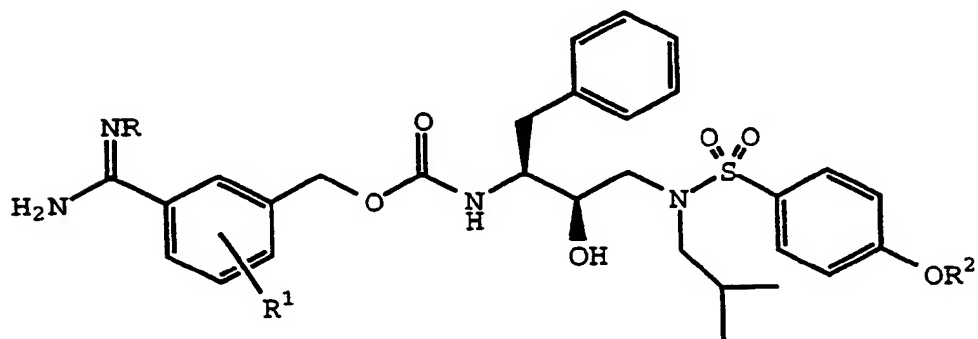
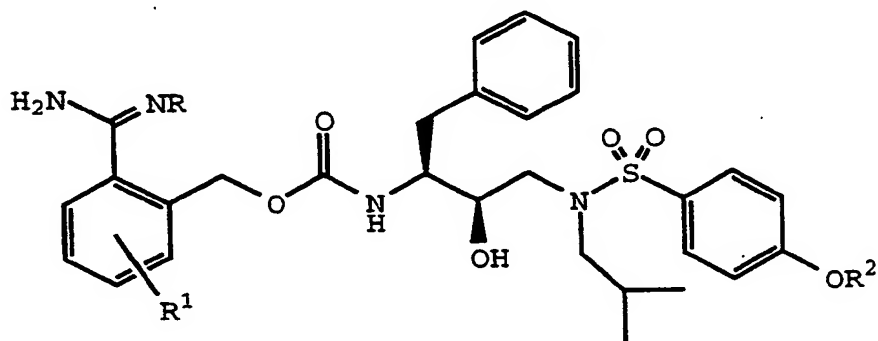
5

A

10

TABLE 17B

- 5 R = H or OH
R¹ = CH₃, NH₂, F, Cl or Br
R² = H or CH₃



10

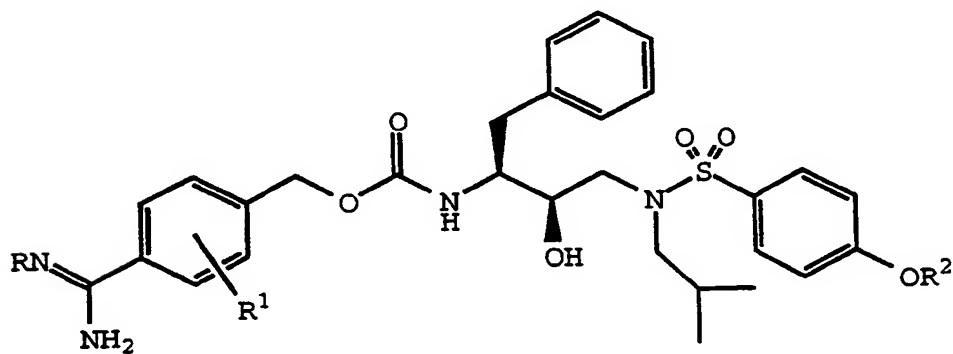
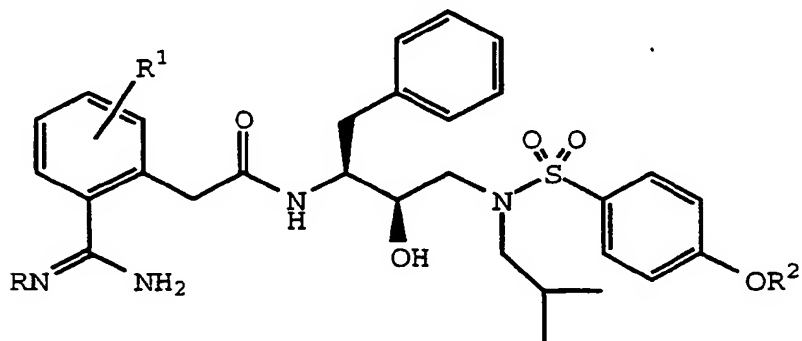
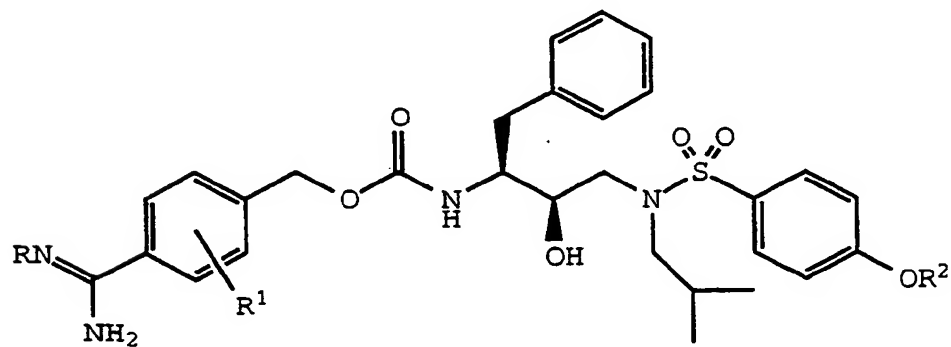
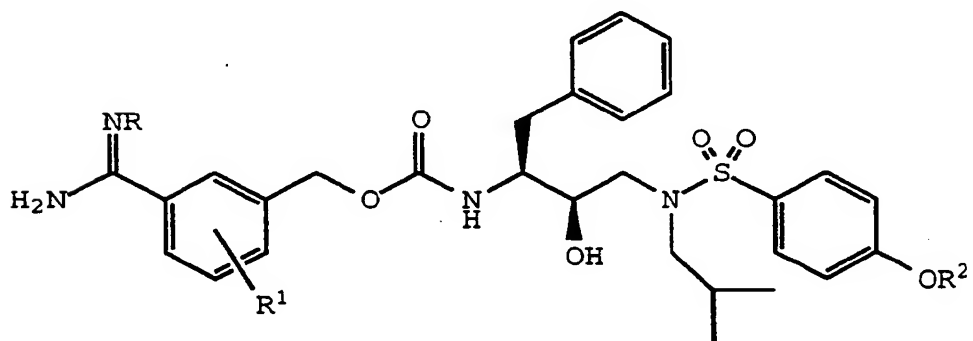
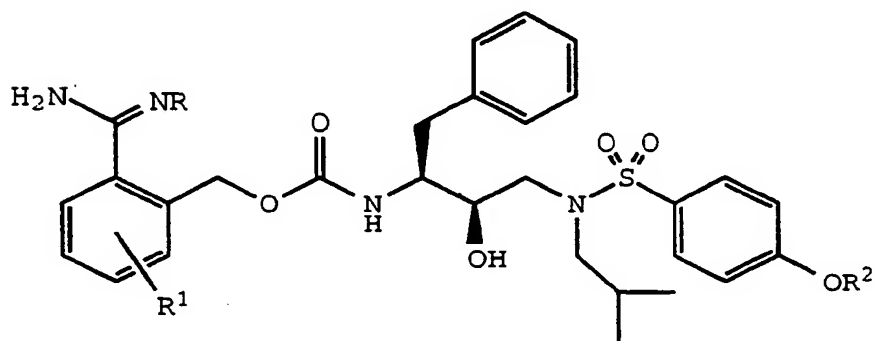


TABLE 17B (Cont.)

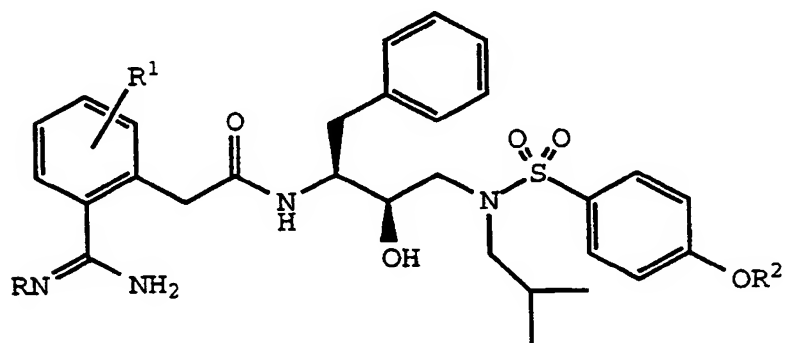


5

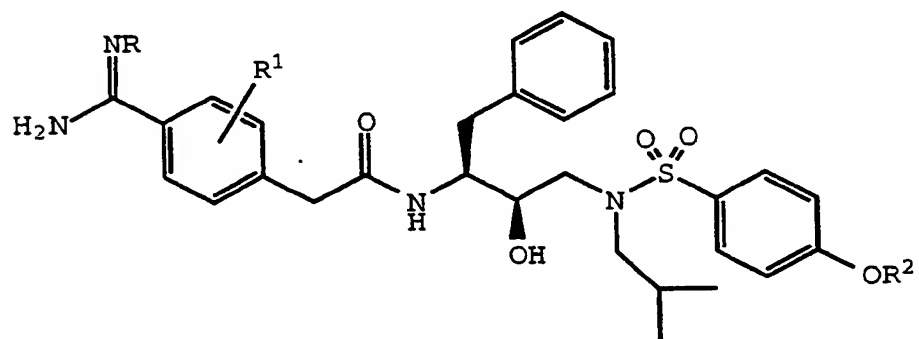
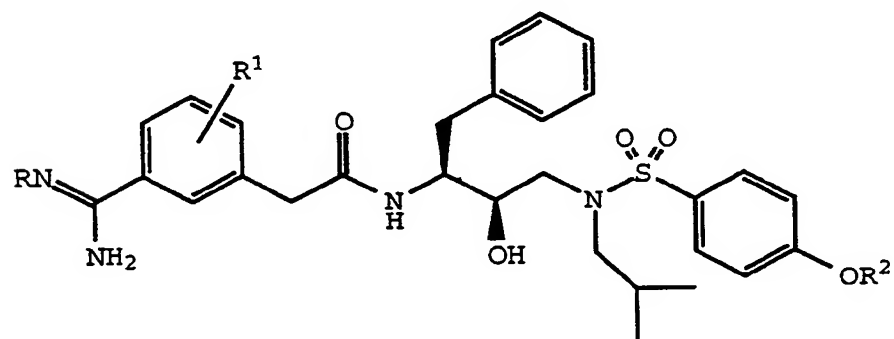


10

TABLE 17B (Cont.)



5



Example 23

The compounds of the present invention are effective HIV protease inhibitors. Utilizing an enzyme assay as described below, the compounds set forth in the examples herein disclosed inhibited the HIV enzyme. The preferred compounds of the present invention and their calculated IC₅₀ (inhibiting concentration 50%, i.e., the concentration at which the inhibitor compound reduces enzyme activity by 50%) values are shown in Tables 18 through 21. The enzyme method is described below. The substrate is 2-Ile-Nle-Phe(p-NO₂)-Gln-ArgNH₂. The positive control is MVT-101 (Miller, M. et al, Science, 246, 1149 (1989)) The assay conditions are as follows:

15

Assay buffer: 20 mM sodium phosphate, pH 6.4
20% glycerol
1 mM EDTA
1 mM DTT
0.1% CHAPS

20

The above described substrate is dissolved in DMSO, then diluted 10 fold in assay buffer. Final substrate concentration in the assay is 80 μ M.

25

HIV protease is diluted in the assay buffer to a final enzyme concentration of 12.3 nanomolar, based on a molecular weight of 10,780.

30

The final concentration of DMSO is 14% and the final concentration of glycerol is 18%. The test compound is dissolved in DMSO and diluted in DMSO to 10x the test concentration; 10 μ l of the enzyme preparation is added, the materials mixed and then the mixture is incubated at ambient temperature for 15 minutes. The enzyme reaction is initiated by the addition of 40 μ l of substrate. The increase in fluorescence is monitored at 4 time points (0, 8, 16 and 24 minutes) at ambient temperature. Each assay is carried out in duplicate

35

wells.

The preceding examples can be repeated with similar success by substituting the generically or specifically described reactants and/or operating conditions of this invention for those used in the preceding examples.

10

TABLE 18A

15

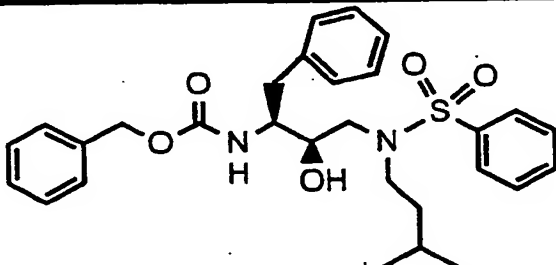
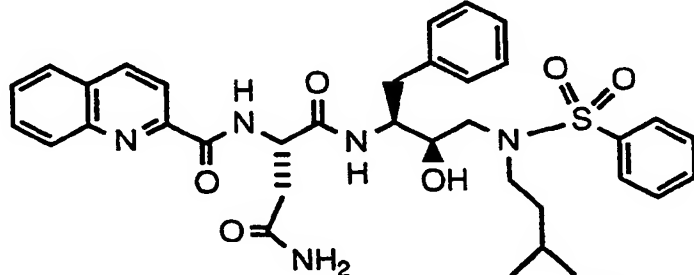
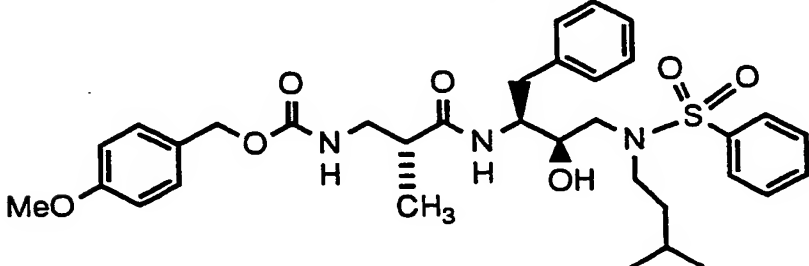
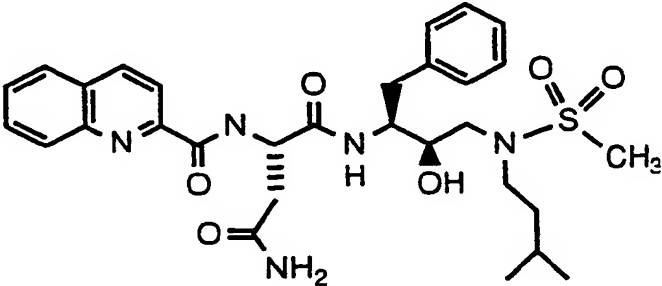
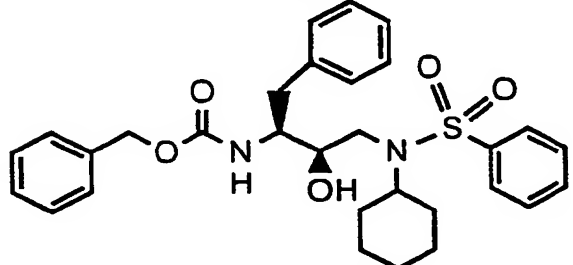
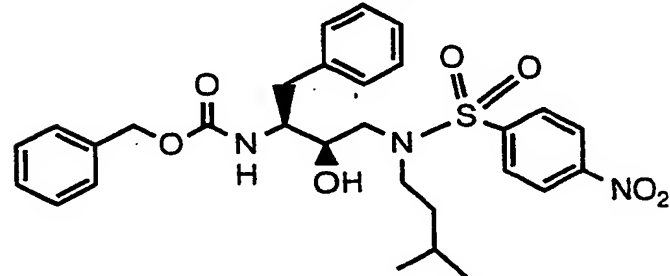
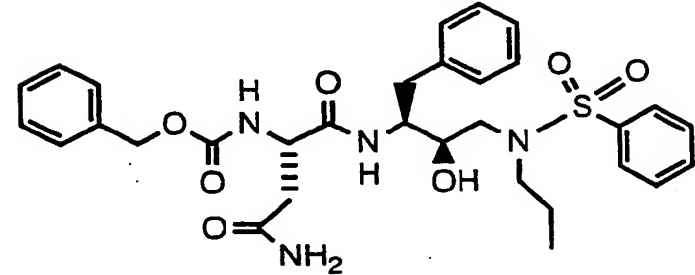
Entry	Compound	IC ₅₀ (nanomolar)
1		16
2		1.5
3		1.4

TABLE 18A (Cont'd)

Entry	Compound	IC ₅₀ (nanomolar)
4		27
5		19
6		10
7		3.6

10

TABLE 18A (Cont'd)

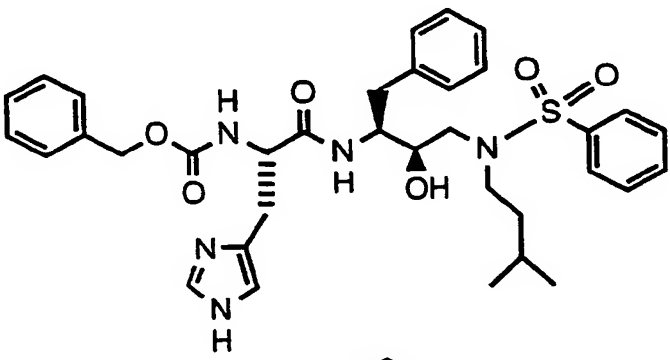
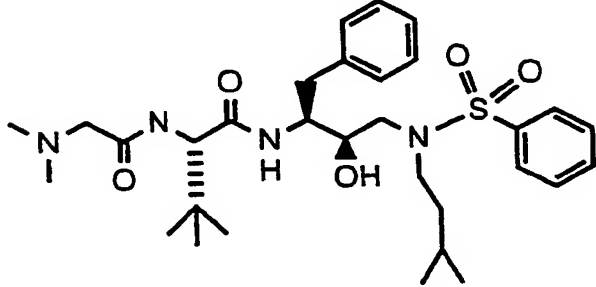
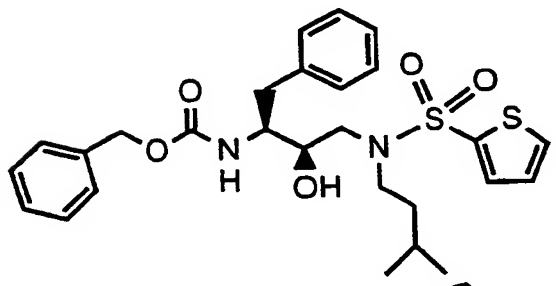
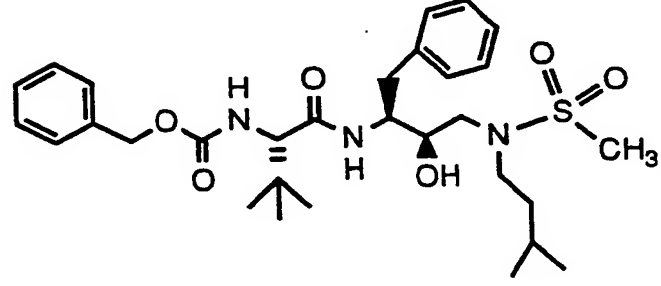
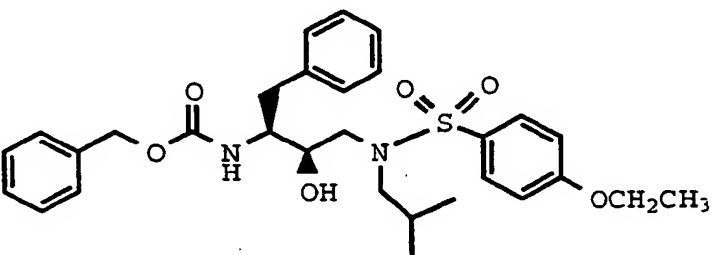
Entry	Compound	IC ₅₀ (nanomolar)
5		
8		4.2
9		3.5
10		100
11		81

TABLE 18A (Cont'd)

Entry	Compound	IC ₅₀ (nanomolar)
12		20

10

TABLE 19B

Ex.	Table	Entry	IC ₅₀ (uM) or % inhib
15			
6	1a	1	0.011
6	1a	2	0.010
20	6	1a	38% @ 1 uM, 79% @ 10 uM
6	1a	4	0.016
6	1a	5	0.10
25	6	1a	36% @ 10 uM
6	1a	7	0.0096
30	6	1a	0.016
6	1a	40	0.21
6	1a	41	24% @ 1 uM, 74% @ 10 uM
35	6	1a	42% @ 1 uM, 89% @ 10 uM
6	1a	51	31% @ 1 uM, 76% @ 10 uM
40	6	1a	39% @ 1 uM, 81% @ 10 uM
6	1a	53	0.049
6	1a	54	0.0028

TABLE 19B (Cont'd)

	Ex.	Table	Entry	IC ₅₀ (uM) or % inhib
5				
	6	1a	55	0.10
	6	1a	56	0.0036
10	16	3	1	0.081
	16	3	2	38% @ 0.1 uM, 90% @ 1.0 uM
15	16	3	4	0.0024
	16	3	6	0.0018
	16	3	8	0.003
20	16	3	10	0.0025
	16	3	12	0.0016
25	16	4	102	0.0015
	16	5	1	0.0014
	16	5	14	0.0022
30	16	5	22	0.0018
	16	5	33	0.0044
35	16	5	34	0.0020
	16	7	31	0.0028
	16	7	32	0.0015
40	16	11	1	0.13
	16	11	9	41% @ 0.1 uM, 86% @ 1 uM
45	16	12	10	0.0033
	16	14	3	0.0049
	16	14	10	0.0032
50				

TABLE 20

	Table	Entry	IC ₅₀ (uM) or % inhibition
5	1A	3	0.02
	5A	1	0.04
	5A	3	0.02
10	5A	4	0.01
	5A	5	0.026
	5A	6	0.023
	5A	7	0.007
	5A	9	0.067
15	5A	11	0.018
	5A	12	0.006
	5A	13	0.0098
	5A	14	0.049
	5A	16	0.008
20	5A	17	59% @ 10μM
	5A	18	0.13
	5A	19	0.092
	5A	20	85% @ 1μM
	5A	22	63% @ 1μM
25	5A	24	0.047
	5A	25	0.014
	5A	26	0.005
	5A	28	0.015
	5A	29	0.19
30	5A	30	0.03
	5A	31	0.02

Example 24

35

The effectiveness of various compounds were determined in the above-described enzyme assay and in a CEM cell assay.

The HIV inhibition assay method of acutely infected cells is an automated tetrazolium based colorimetric assay essentially that reported by Pauwles et al, J. Virol. Methods, 20, 309-321 (1988). Assays were performed in 96-well tissue culture plates. CEM cells, a CD4⁺ cell line, were grown in RPMI-1640 medium (Gibco) supplemented with a 10% fetal calf serum and were then treated with polybrene (2µg/ml). An 80 µl volume of medium containing 1×10^4 cells was dispensed into each well of the tissue culture plate. To each well was added a 100µl volume of test compound dissolved in tissue culture medium (or medium without test compound as a control) to achieve the desired final concentration and the cells were incubated at 37°C for 1 hour. A frozen culture of HIV-1 was diluted in culture medium to a concentration of 5×10^4 TCID₅₀ per ml (TCID₅₀ = the dose of virus that infects 50% of cells in tissue culture), and a 20µL volume of the virus sample (containing 1000 TCID₅₀ of virus) was added to wells containing test compound and to wells containing only medium (infected control cells). Several wells received culture medium without virus (uninfected control cells). Likewise, the intrinsic toxicity of the test compound was determined by adding medium without virus to several wells containing test compound. In summary, the tissue culture plates contained the following experiments:

	Cells	Drug	Virus
1.	+	-	-
2.	+	+	-
3.	+	-	+
4.	+	+	+

35

In experiments 2 and 4 the final concentrations of test compounds were 1, 10, 100 and 500 µg/ml. Either azidothymidine (AZT) or dideoxyinosine (ddI) was included as a positive drug control. Test compounds were

dissolved in DMSO and diluted into tissue culture medium so that the final DMSO concentration did not exceed 1.5% in any case. DMSO was added to all control wells at an appropriate concentration.

5

Following the addition of virus, cells were incubated at 37°C in a humidified, 5% CO₂ atmosphere for 7 days. Test compounds could be added on days 0, 2 and 5 if desired. On day 7, post-infection, the cells in each well were resuspended and a 100µl sample of each cell suspension was removed for assay. A 20µL volume of a 5 mg/ml solution of 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide (MTT) was added to each 100µL cell suspension, and the cells were incubated for 4 hours at 27°C in a 5% CO₂ environment. During this incubation, MTT is metabolically reduced by living cells resulting in the production in the cell of a colored formazan product. To each sample was added 100µl of 10% sodium dodecylsulfate in 0.01 N HCl to lyse the cells, and samples were incubated overnight. The absorbance at 590 nm was determined for each sample using a Molecular Devices microplate reader. Absorbance values for each set of wells is compared to assess viral control infection, uninfected control cell response as well as test compound by cytotoxicity and antiviral efficacy.

25

TABLE 21

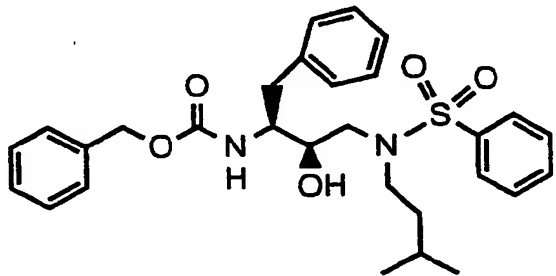
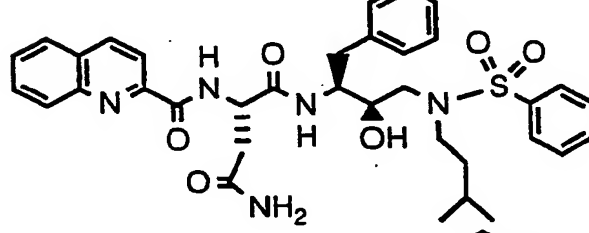
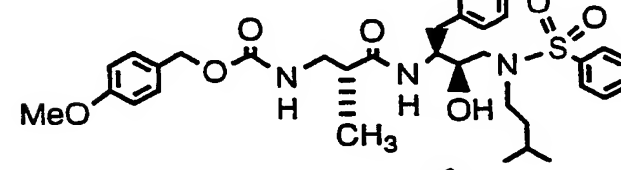
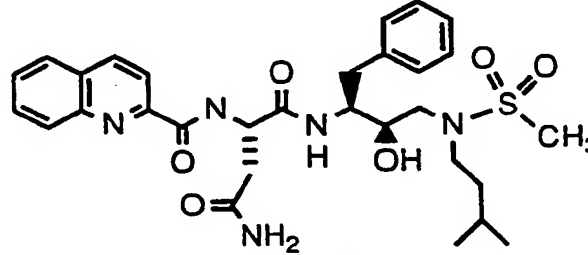
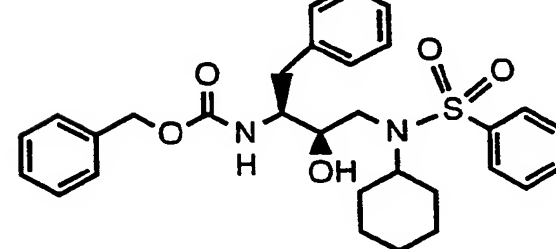
Entry	Compound	IC ₅₀ (nM)	EC ₅₀ (nM)	TD ₅₀ (nM)
1		16	55	27
2		1	5	203
3		1	11	780
4		27	64	28
5		19	88	11

TABLE 21 (Cont'd)

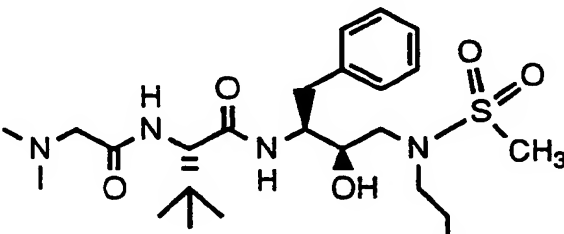
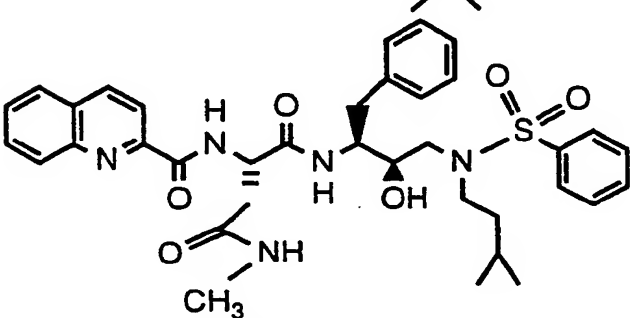
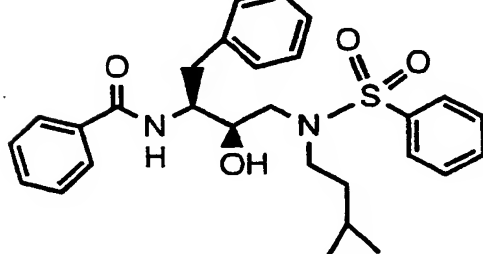
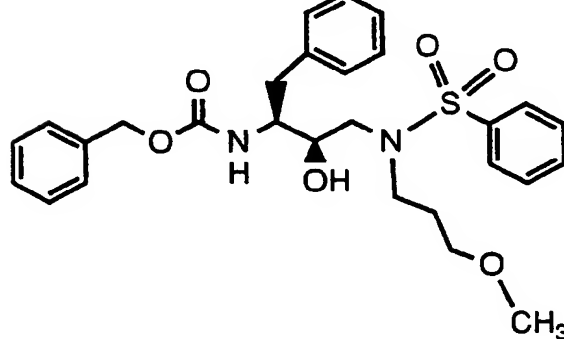
Entry	Compound	IC ₅₀ (nM)	EC ₅₀ (nM)	TD ₅₀ (nM)
5				
6		>100	380	425
7		3	25	39
8		85	1200	24
9		53	398	15

TABLE 21 (Cont'd)

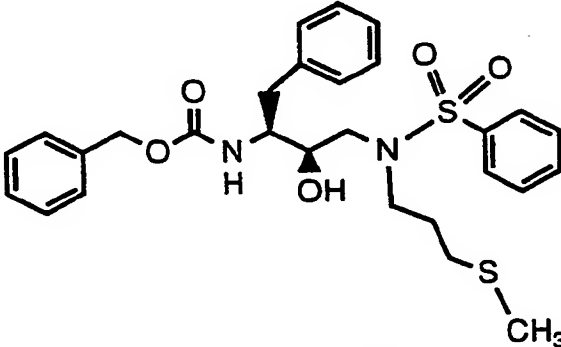
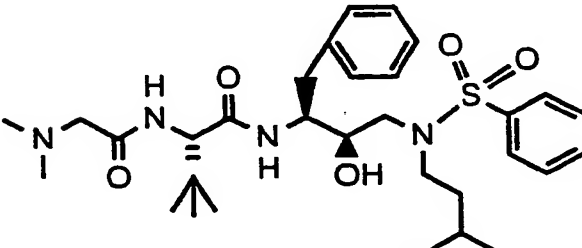
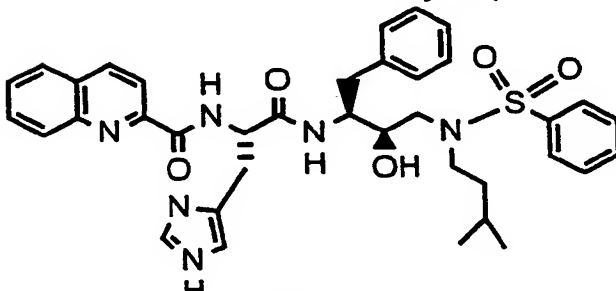
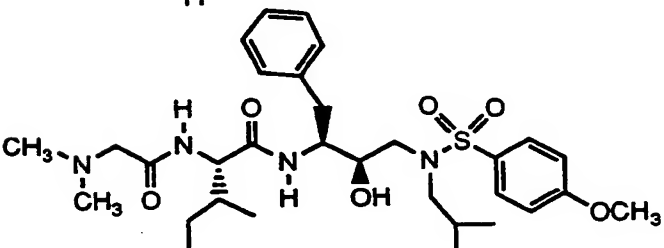
Entry	Compound	IC ₅₀ (nM)	EC ₅₀ (nM)	TD ₅₀ (nM)	
5					
10		45	700	12	
11		3	11	54	
12		2	12	7.5	
10	13		3	<16	

TABLE 21 (Cont'd)

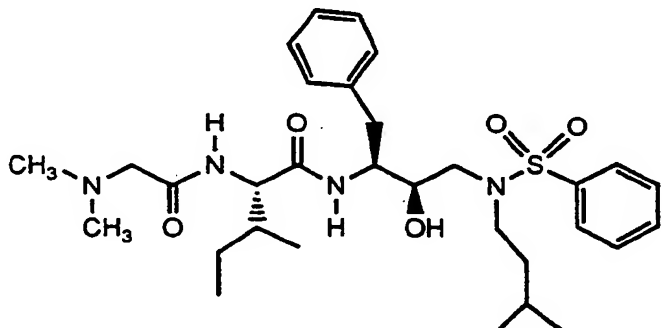
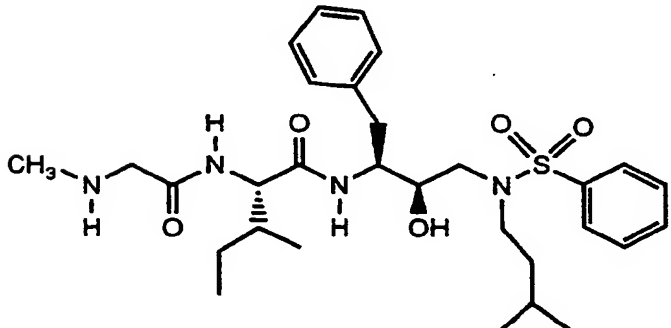
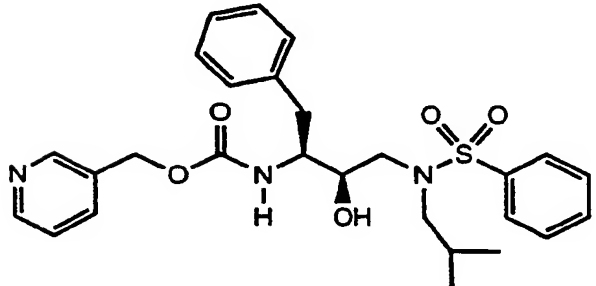
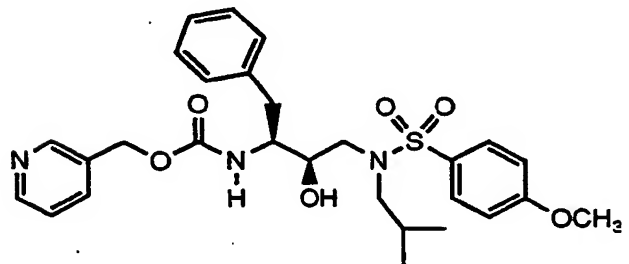
Entry	Compound	IC ₅₀ (nM)	EC ₅₀ (nM)	TD ₅₀ (nM)
14		4	15	55,000
15		5	38	
16		9	80	62,000
17		4	5	59,000

TABLE 21 (Cont'd)

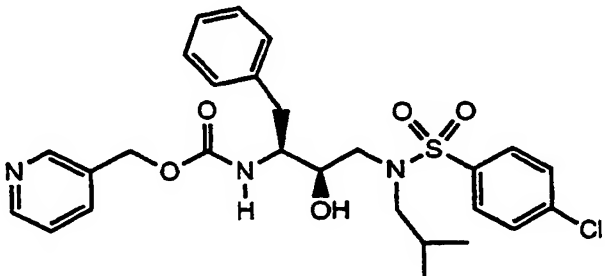
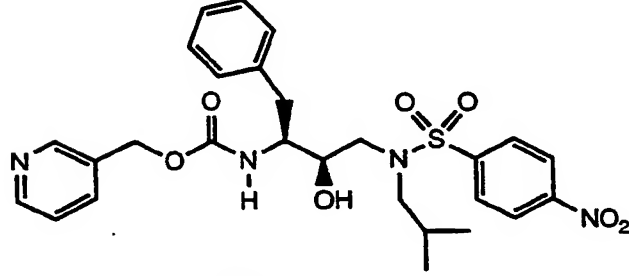
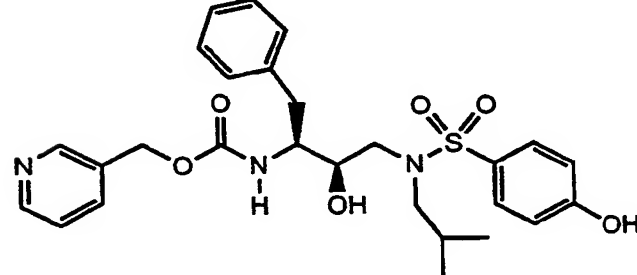
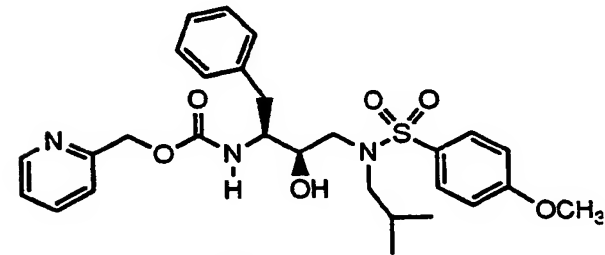
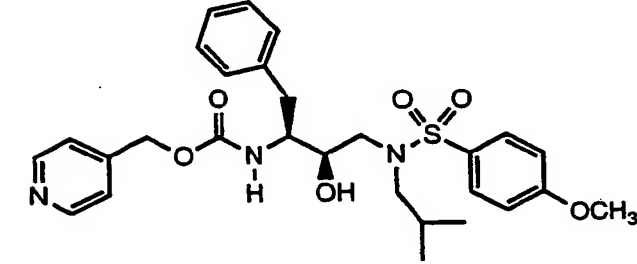
Entry	Compound	IC ₅₀ (nM)	EC ₅₀ (nM)	TD ₅₀ (nM)
18		4	154	
19		8	377	
20		4	13	
21		73		
22		15	18	31,000

TABLE 21 (Cont'd)

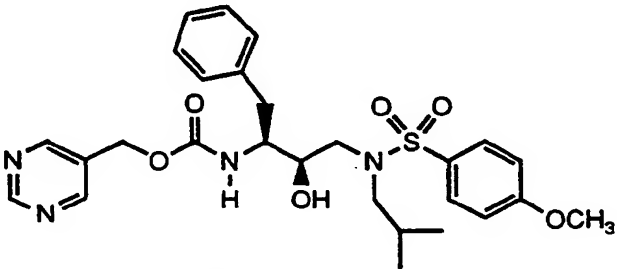
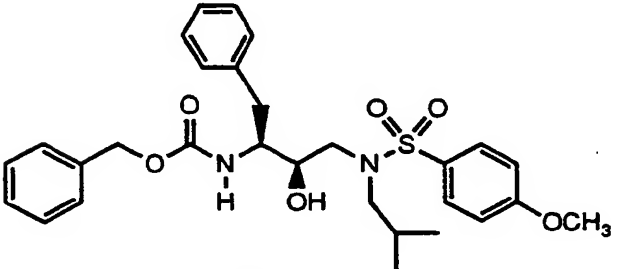
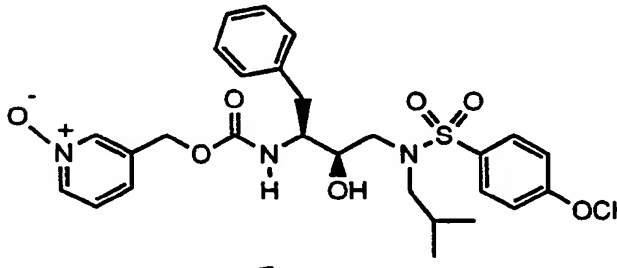
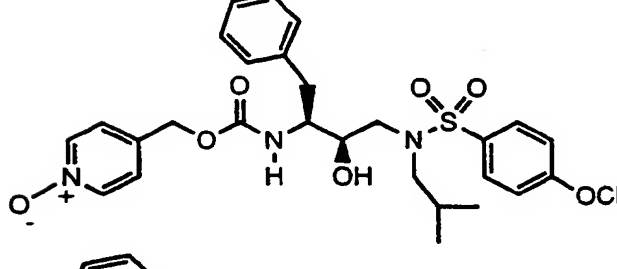
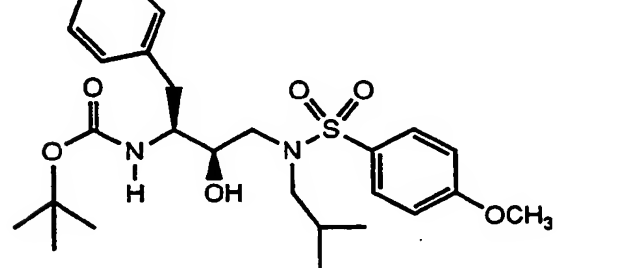
Entry	Compound	IC ₅₀ (nM)	EC ₅₀ (nM)	TD ₅₀ (nM)
5				
23		2	8	
24		3		
25		60	120	167,000
26		68		
27		5	177	300,000

TABLE 21 (Cont'd)

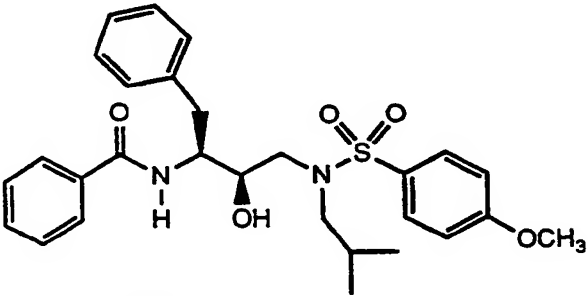
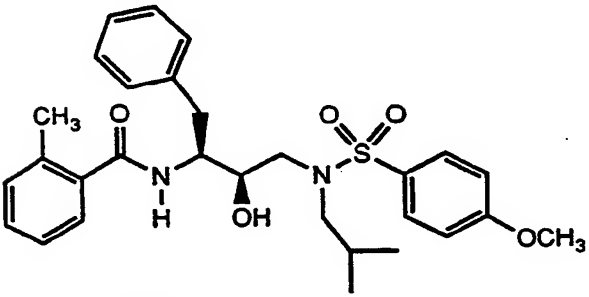
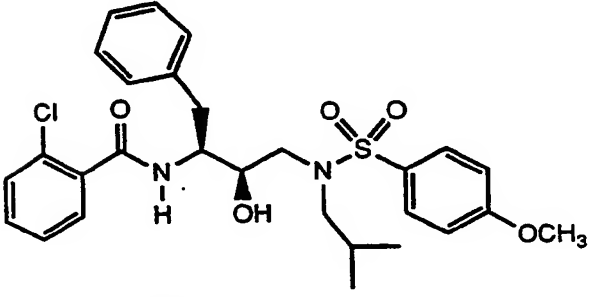
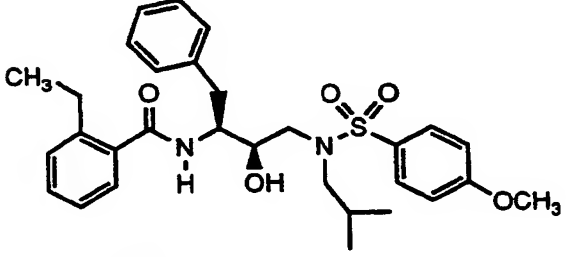
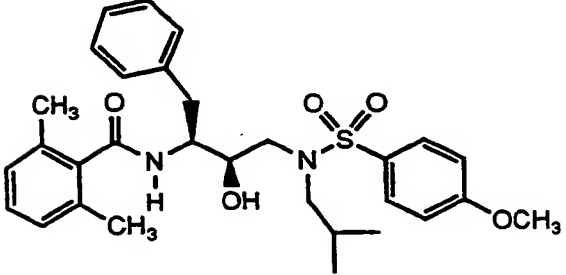
Entry	Compound	IC ₅₀ (nM)	EC ₅₀ (nM)	TD ₅₀ (nM)
28		14	76	213,000
29		5	105	196,000
30		6	154	154,000
31		10		
32		5	98	17,000

TABLE 21 (Cont'd)

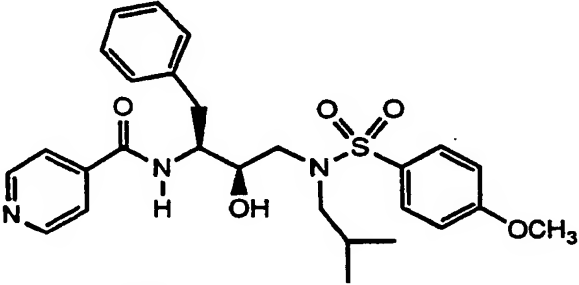
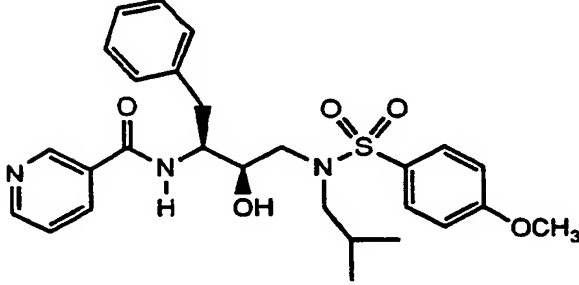
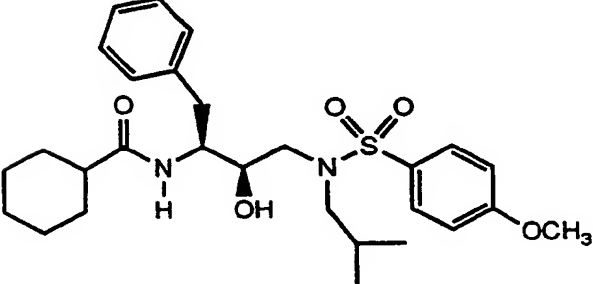
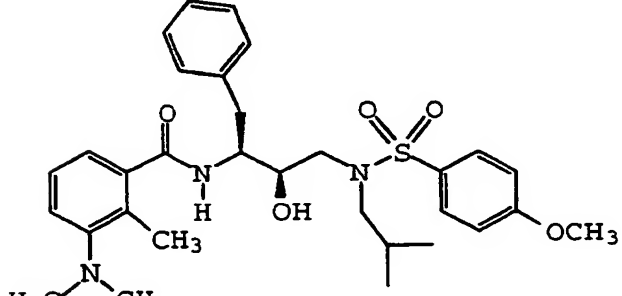
Entry	Compound	IC ₅₀ (nM)	EC ₅₀ (nM)	TD ₅₀ (nM)
5				
33		18	68	
34		67	188	
35		18		
36		310	898	

TABLE 21 (Cont'd)

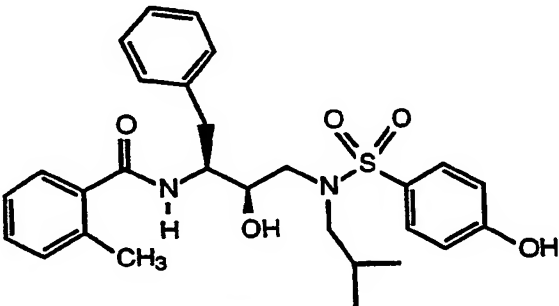
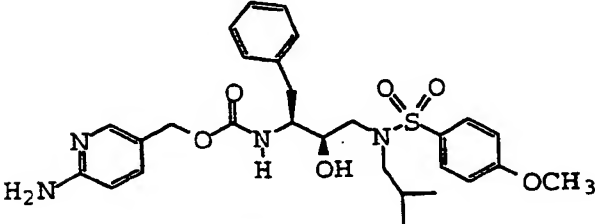
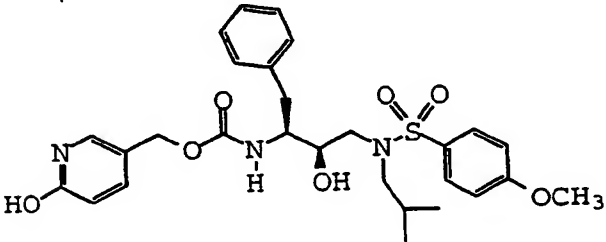
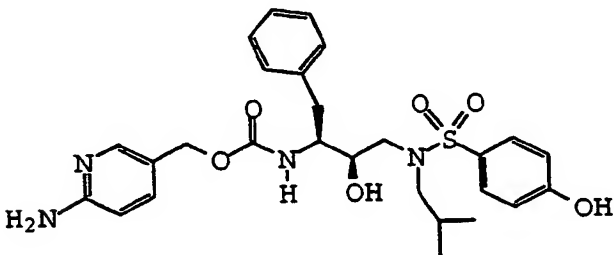
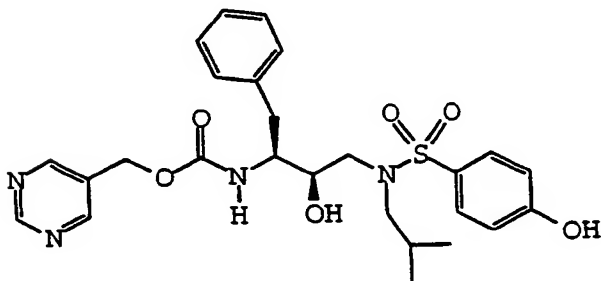
Entry	Compound	IC ₅₀ (nM)	EC ₅₀ (nM)	TD ₅₀ (nM)
37		7	<20	
38		4	1,100	
39		16	269	
40		3		
41		3	11	

TABLE 21 (Cont'd)

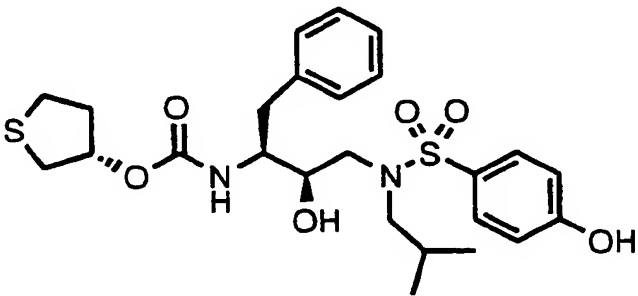
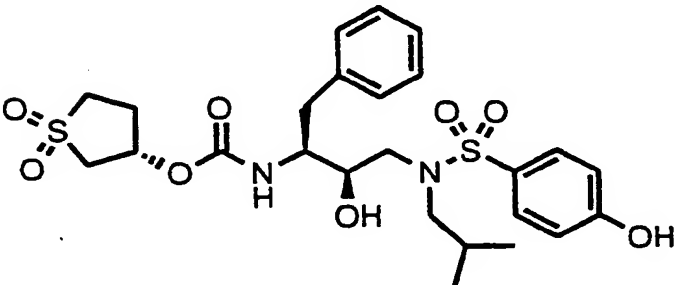
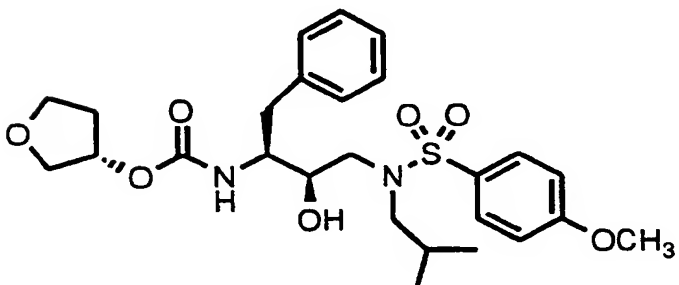
Entry	Compound	IC ₅₀ (nM)	EC ₅₀ (nM)	TD ₅₀ (nM)
5				
42		2	<20	
43		4	63	
44		4	8	
10	45	2	5	

TABLE 21 (Cont'd)

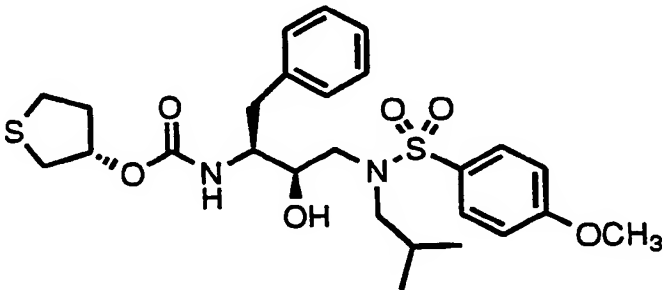
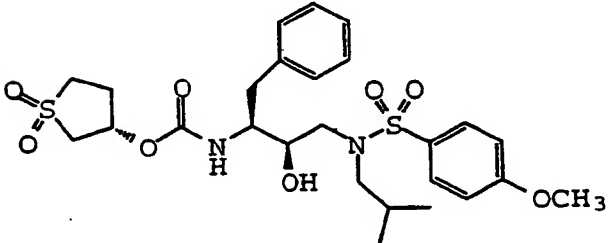
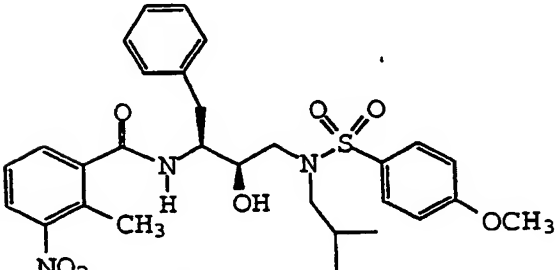
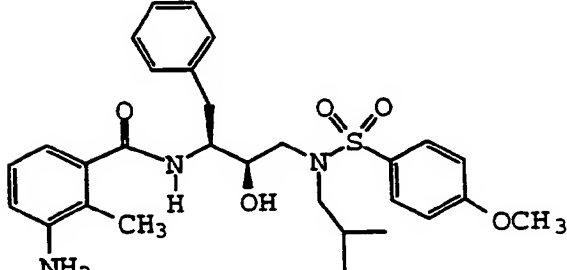
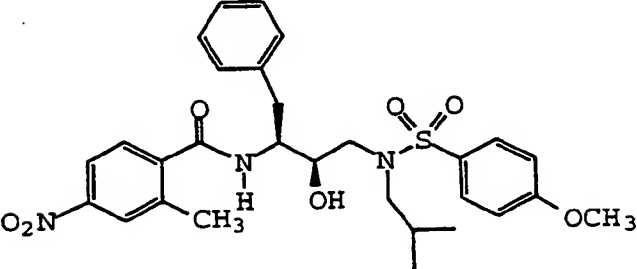
Entry	Compound	IC ₅₀ (nM)	EC ₅₀ (nM)	TD ₅₀ (nM)
46		2	<20	
47		3	<20	
48		17	210	
49		6	<20	
50		14		

TABLE 21 (Cont'd)

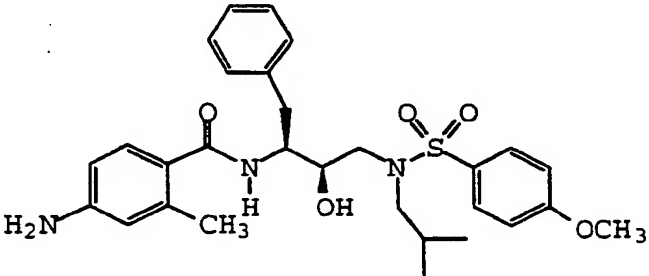
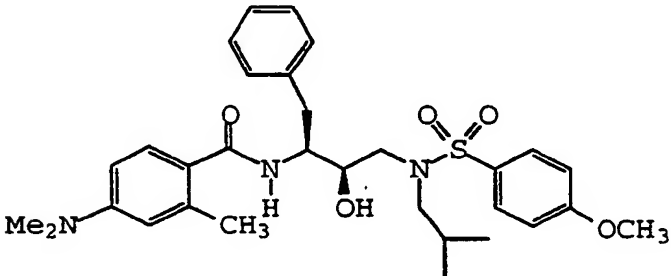
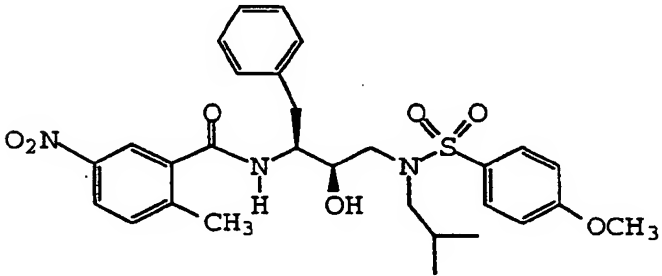
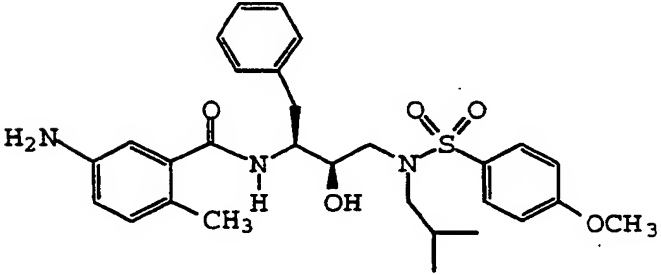
Entry	Compound	IC ₅₀ (nM)	EC ₅₀ (nM)	TD ₅₀ (nM)
51		9	<20	
52		>100		
53		21		
54		10		

TABLE 21 (Cont'd)

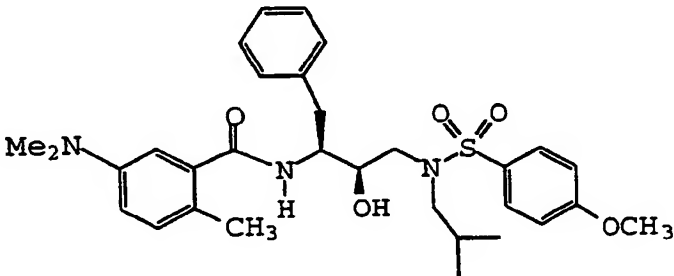
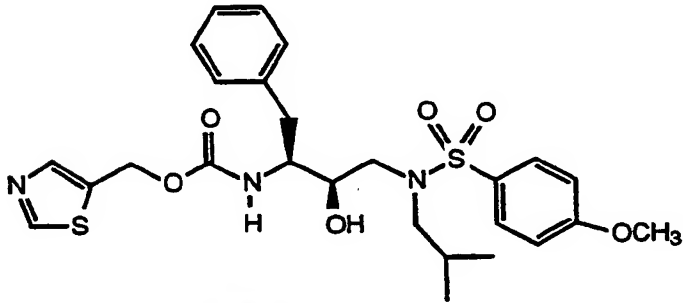
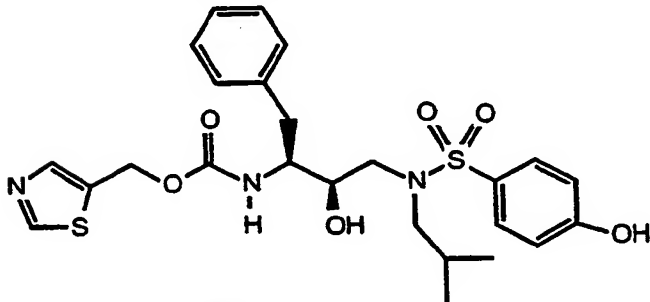
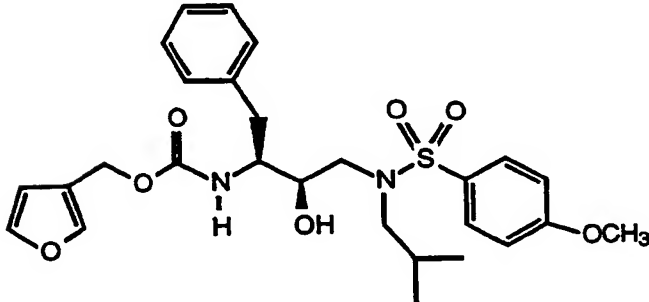
Entry	Compound	IC ₅₀ (nM)	EC ₅₀ (nM)	TD ₅₀ (nM)
55		37		
56		4	40	
57		4	<20	
58		2	70	

TABLE 21 (Cont'd)

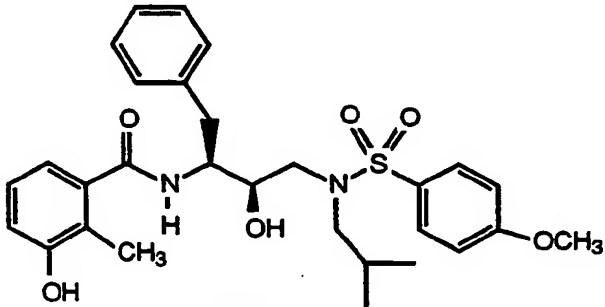
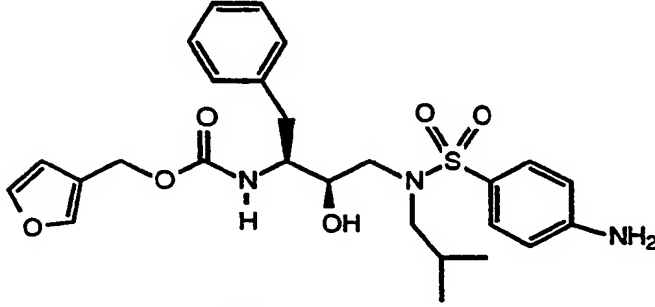
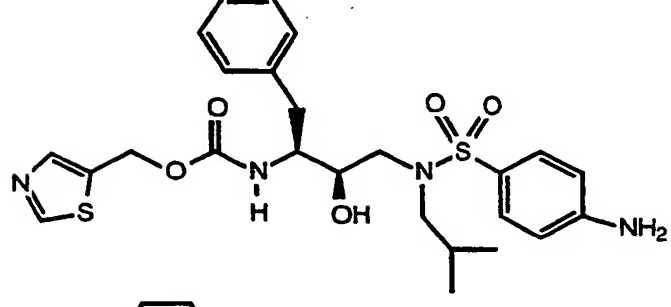
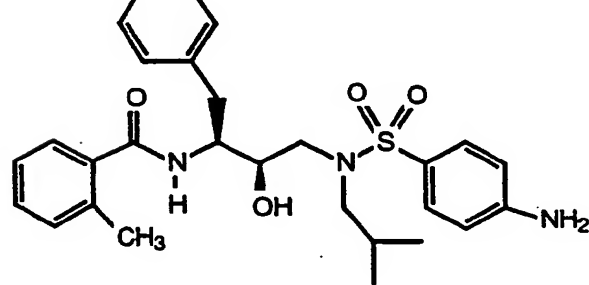
Entry	Compound	IC ₅₀ (nM)	EC ₅₀ (nM)	TD ₅₀ (nM)
59		3	22	
60		5	60	
61		16		
62		28		

TABLE 21 (Cont'd)

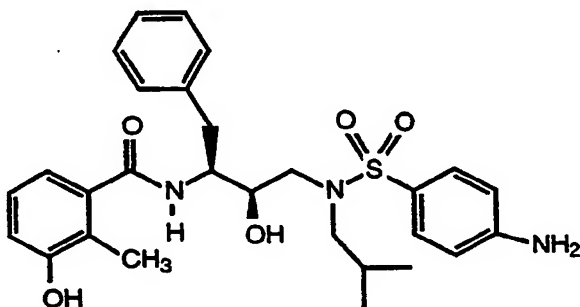
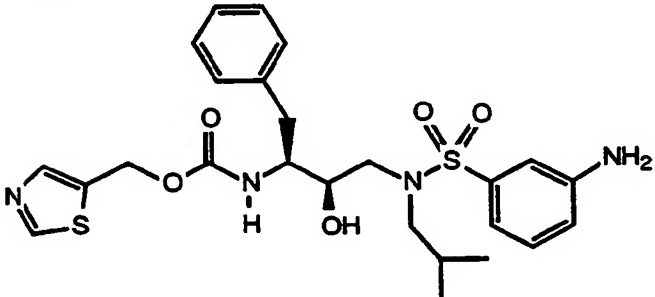
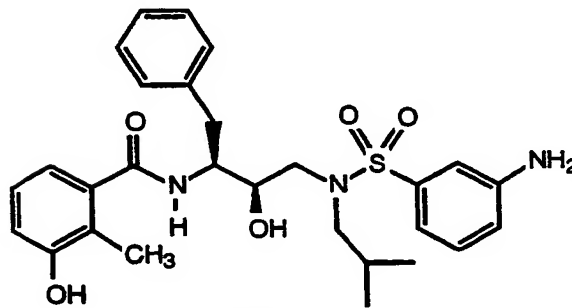
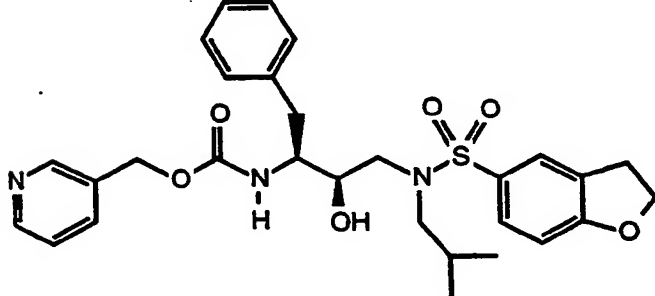
Entry	Compound	IC ₅₀ (nM)	EC ₅₀ (nM)	TD ₅₀ (nM)	
5					
63		7			
64		7			
65		4			
10	66		4		

TABLE 21 (Cont'd)

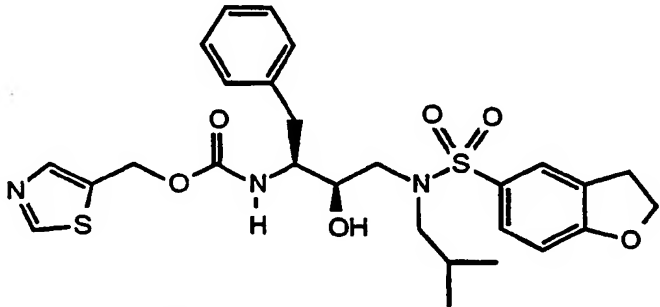
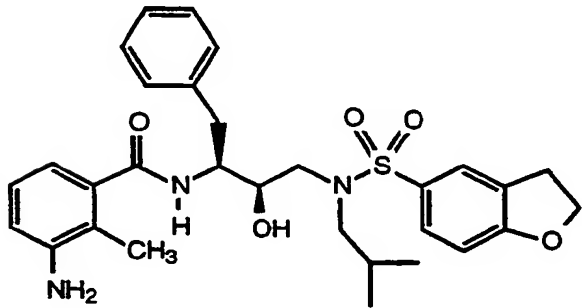
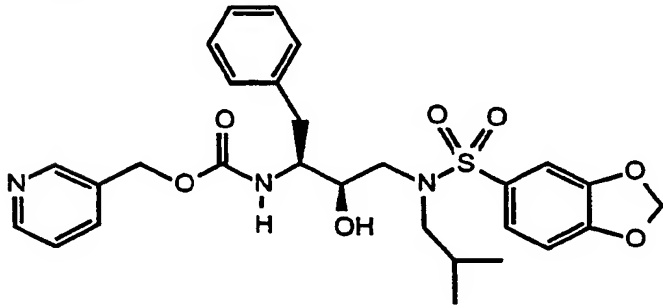
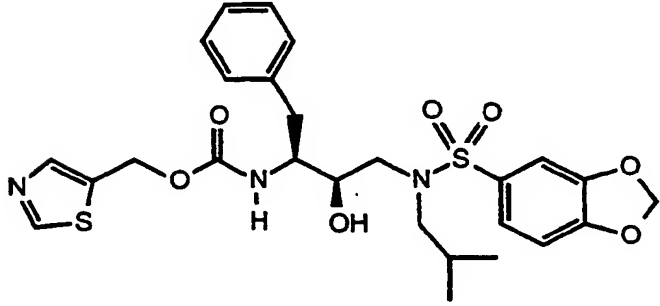
Entry	Compound	IC ₅₀ (nM)	EC ₅₀ (nM)	TD ₅₀ (nM)
5				
67			5	
				
68			7	
				
69			4	68
				
10	70		5	30

TABLE 21 (Cont'd)

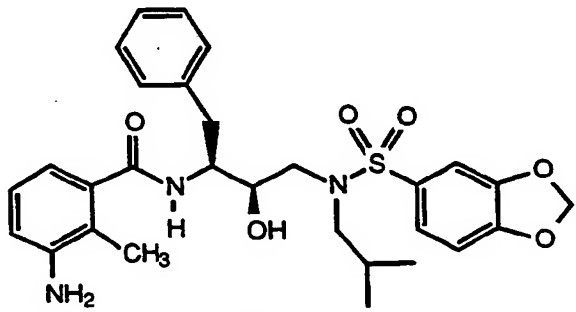
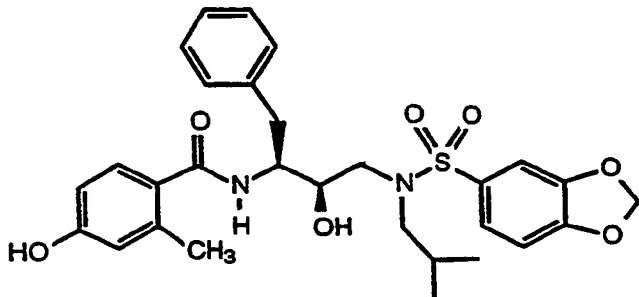
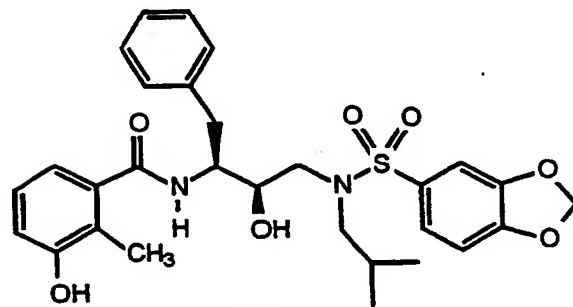
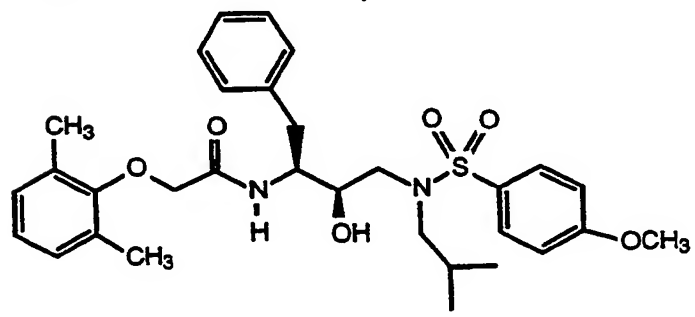
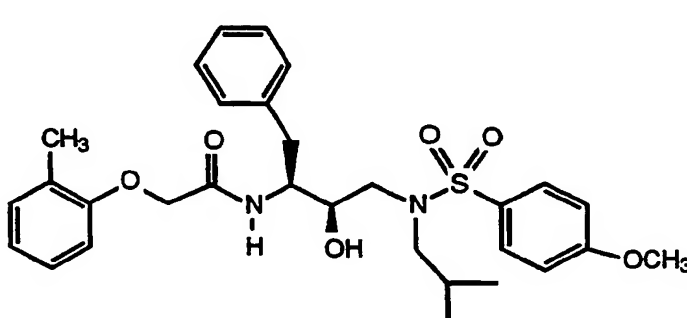
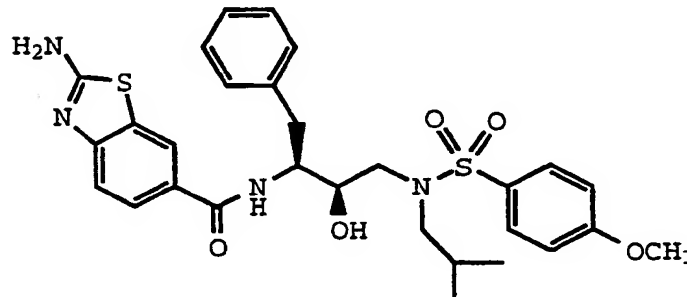
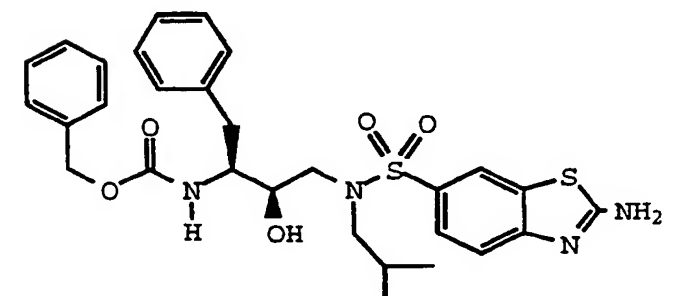
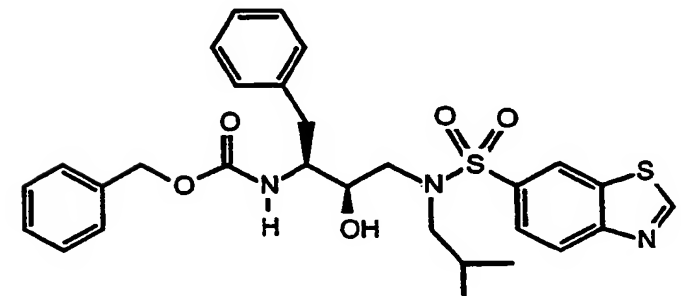
Entry	Compound	IC ₅₀ (nM)	EC ₅₀ (nM)	TD ₅₀ (nM)
5				
71			5	
				
72			5	42
				
73			4	22
				
10 74			3	

TABLE 21 (Cont'd)

Entry	Compound	IC ₅₀ (nM)	EC ₅₀ (nM)	TD ₅₀ (nM)
5				
75		8		
76		5		
77		2		
78		3		

10

78

3

The compounds of the present invention are effective antiviral compounds and, in particular, are effective retroviral inhibitors as shown above. Thus, the subject compounds are effective HIV protease inhibitors. It is contemplated that the subject compounds will also inhibit other retroviruses such as other lentiviruses in particular other strains of HIV, e.g. HIV-2, human T-cell leukemia virus, respiratory syncytial virus, simia immunodeficiency virus, feline leukemia virus, feline immuno-deficiency virus, hepadnavirus, cytomegalovirus and picornavirus. Thus, the subject compounds are effective in the treatment and/or prophylaxis of retroviral infections.

The subject compounds are also effective in preventing the growth of retroviruses in a solution. Both human and animal cell cultures, such as T-lymphocyte cultures, are utilized for a variety of well known purposes, such as research and diagnostic procedures including calibrators and controls. Prior to and during the growth and storage of a cell culture, the subject compounds may be added to the cell culture medium at an effective concentration to prevent the unexpected or undesired replication of a retrovirus that may inadvertently or unknowingly be present in the cell culture. The virus may be present originally in the cell culture, for example HIV is known to be present in human T-lymphocytes long before it is detectable in blood, or through exposure to the virus. This use of the subject compounds prevents the unknowing or inadvertent exposure of a potentially lethal retrovirus to a researcher or clinician.

Compounds of the present invention can possess one or more asymmetric carbon atoms and are thus capable of existing in the form of optical isomers as well as in the form of racemic or nonracemic mixtures thereof. The optical isomers can be obtained by resolution of the

racemic mixtures according to conventional processes, for example by formation of diastereoisomeric salts by treatment with an optically active acid or base.

Examples of appropriate acids are tartaric,

- 5 diacetyltartaric, dibenzoyltartaric, ditoluoyltartaric and camphorsulfonic acid and then separation of the mixture of diastereoisomers by crystallization followed by liberation of the optically active bases from these salts. A different process for separation of optical
- 10 isomers involves the use of a chiral chromatography column optimally chosen to maximize the separation of the enantiomers. Still another available method involves synthesis of covalent diastereoisomeric molecules by reacting compounds of Formula I with an optically pure
- 15 acid in an activated form or an optically pure isocyanate. The synthesized diastereoisomers can be separated by conventional means such as chromatography, distillation, crystallization or sublimation, and then hydrolyzed to deliver the enantiomerically pure compound.
- 20 The optically active compounds of Formula I can likewise be obtained by utilizing optically active starting materials. These isomers may be in the form of a free acid, a free base, an ester or a salt.

- 25 The compounds of the present invention can be used in the form of salts derived from inorganic or organic acids. These salts include but are not limited to the following: acetate, adipate, alginate, citrate, aspartate, benzoate, benzenesulfonate, bisulfate,
- 30 butyrate, camphorate, camphorsulfonate, digluconate, cyclopentanepropionate, dodecylsulfate, ethanesulfonate, glucoheptanoate, glycerophosphate, hemisulfate, heptanoate, hexanoate, fumarate, hydrochloride, hydrobromide, hydroiodide, 2-hydroxy-ethanesulfonate,
- 35 lactate, maleate, methanesulfonate, nicotinate, 2-naphthalenesulfonate, oxalate, palmoate, pectinate, persulfate, 3-phenylpropionate, picrate, pivalate, propionate, succinate, tartrate, thiocyanate, tosylate,

mesylate and undecanoate. Also, the basic nitrogen-containing groups can be quaternized with such agents as lower alkyl halides, such as methyl, ethyl, propyl, and butyl chloride, bromides, and iodides; dialkyl sulfates like dimethyl, diethyl, dibutyl, and diamyl sulfates, long chain halides such as decyl, lauryl, myristyl and stearyl chlorides, bromides and iodides, aralkyl halides like benzyl and phenethyl bromides, and others. Water or oil-soluble or dispersible products are thereby obtained.

10

Examples of acids which may be employed to form pharmaceutically acceptable acid addition salts include such inorganic acids as hydrochloric acid, sulphuric acid and phosphoric acid and such organic acids as oxalic acid, maleic acid, succinic acid and citric acid. Other examples include salts with alkali metals or alkaline earth metals, such as sodium, potassium, calcium or magnesium or with organic bases.

20

Total daily dose administered to a host in single or divided doses may be in amounts, for example, from 0.001 to 10 mg/kg body weight daily and more usually 0.01 to 1 mg. Dosage unit compositions may contain such amounts of submultiples thereof to make up the daily dose.

25

The amount of active ingredient that may be combined with the carrier materials to produce a single dosage form will vary depending upon the host treated and the particular mode of administration.

30

The dosage regimen for treating a disease condition with the compounds and/or compositions of this invention is selected in accordance with a variety of factors, including the type, age, weight, sex, diet and medical condition of the patient, the severity of the disease, the route of administration, pharmacological considerations such as the activity, efficacy,

35

pharmacokinetic and toxicology profiles of the particular compound employed, whether a drug delivery system is utilized and whether the compound is administered as part of a drug combination. Thus, the dosage regimen actually
5 employed may vary widely and therefore may deviate from the preferred dosage regimen set forth above.

The compounds of the present invention may be administered orally, parenterally, by inhalation spray,
10 rectally, or topically in dosage unit formulations containing conventional nontoxic pharmaceutically acceptable carriers, adjuvants, and vehicles as desired. Topical administration may also involve the use of transdermal administration such as transdermal patches or
15 iontophoresis devices. The term parenteral as used herein includes subcutaneous injections, intravenous, intramuscular, intrasternal injection, or infusion techniques.

Injectable preparations, for example, sterile injectable aqueous or oleaginous suspensions may be formulated according to the known art using suitable dispersing or wetting agents and suspending agents. The sterile injectable preparation may also be a sterile
25 injectable solution or suspension in a nontoxic parenterally acceptable diluent or solvent, for example, as a solution in 1,3-butanediol. Among the acceptable vehicles and solvents that may be employed are water, Ringer's solution, and isotonic sodium chloride solution.
30 In addition, sterile, fixed oils are conventionally employed as a solvent or suspending medium. For this purpose any bland fixed oil may be employed including synthetic mono- or diglycerides. In addition, fatty acids such as oleic acid find use in the preparation of
35 injectables.

Suppositories for rectal administration of the drug can be prepared by mixing the drug with a suitable

nonirritating excipient such as cocoa butter and polyethylene glycols which are solid at ordinary temperatures but liquid at the rectal temperature and will therefore melt in the rectum and release the drug.

5

Solid dosage forms for oral administration may include capsules, tablets, pills, powders, and granules. In such solid dosage forms, the active compound may be admixed with at least one inert diluent such as sucrose
10 lactose or starch. Such dosage forms may also comprise, as in normal practice, additional substances other than inert diluents, e.g., lubricating agents such as magnesium stearate. In the case of capsules, tablets, and pills, the dosage forms may also comprise buffering
15 agents. Tablets and pills can additionally be prepared with enteric coatings.

Liquid dosage forms for oral administration may include pharmaceutically acceptable emulsions, solutions,
20 suspensions, syrups, and elixirs containing inert diluents commonly used in the art, such as water. Such compositions may also comprise adjuvants, such as wetting agents, emulsifying and suspending agents, and sweetening, flavoring, and perfuming agents.

25

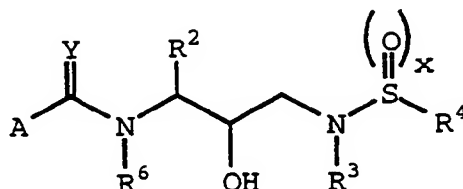
While the compounds of the invention can be administered as the sole active pharmaceutical agent, they can also be used in combination with one or more immunomodulators, antiviral agents or other antiinfective
30 agents. For example, the compounds of the invention can be administered in combination with AZT, DDI, DDC or with glucosidase inhibitors, such as N-butyl-1-deoxynojirimycin or prodrugs thereof, for the prophylaxis and/or treatment of AIDS. When administered as a
35 combination, the therapeutic agents can be formulated as separate compositions which are given at the same time or different times, or the therapeutic agents can be given as a single composition.

The foregoing is merely illustrative of the invention and is not intended to limit the invention to the disclosed compounds. Variations and changes which
5 are obvious to one skilled in the art are intended to be within the scope and nature of the invention which are defined in the appended claims.

From the foregoing description, one skilled in
10 the art can easily ascertain the essential characteristics of this invention, and without departing from the spirit and scope thereof, can make various changes and modifications of the invention to adapt it to various usages and conditions.

WHAT IS CLAIMED IS:

1. A compound represented by the formula:



or a pharmaceutically acceptable salt, prodrug or ester thereof, wherein

10 R² is an alkyl, aryl, cycloalkyl, cycloalkylalkyl or
aralkyl radical, which radical is optionally substituted
with a radical selected from the group consisting of
alkyl, halo, nitro, cyano, CF₃, -OR⁹, and -SR⁹, wherein
R⁹ is a radical selected from the group consisting of
15 hydrogen and alkyl;

R³ is a hydrogen, alkyl, haloalkyl, alkenyl, alkynyl, hydroxyalkyl, alkoxyalkyl, alkylthioalkyl, alkylsulfonylalkyl, cycloalkyl, cycloalkylalkyl, heterocycloalkyl, heteroaryl, heterocycloalkylalkyl, aryl, aralkyl, heteroaralkyl, aminoalkyl or mono- or disubstituted aminoalkyl radicals, wherein said substituents are selected from the group consisting of alkyl, aryl, aralkyl, cycloalkyl, cycloalkylalkyl, heteroaryl, heteroaralkyl, heterocycloalkyl and heterocycloalkylalkyl radicals; or where said aminoalkyl radical is disubstituted, said substituents along with the nitrogen atom to which they are attached, form a heterocycloalkyl or a heteroaryl radical;

30 R⁴ is an alkyl, haloalkyl, alkenyl, alkynyl, hydroxyalkyl, alkoxyalkyl, cycloalkyl, cycloalkylalkyl, heterocycloalkyl, heteroaryl, heterocycloalkylalkyl, aryl, aralkyl, aralkenyl, heteroaralkyl, aminoalkyl or

mono- or disubstituted aminoalkyl radical, wherein said substituents are selected from the group consisting of alkyl, aryl, aralkyl, cycloalkyl, cycloalkylalkyl, heteroaryl, heteroaralkyl, heterocycloalkyl and

- 5 heterocycloalkylalkyl radicals; or where said aminoalkyl radical is disubstituted, said substituents along with the nitrogen atom to which they are attached, form a heterocycloalkyl or a heteroaryl radical;

- 10 R^6 is a hydrogen or alkyl radical;

x is 1 or 2;

t is 0 or 1; and

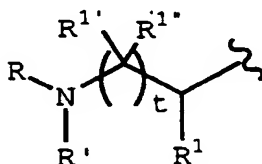
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Y is O or S; and

A is an alkoxy, alkenoxy, aralkoxy, alkyl, cycloalkyl, cycloalkylalkoxy, cycloalkylalkyl, aralkyl, aryl, aryloxy, heterocycloalkyl, heterocycloalkoxy, heterocycloalkylalkyl, heterocycloalkylalkoxy, heteroaralkyl, heteroaralkoxy, heteroaryloxy, heteroaryl, alkenyl, aryloxyalkyl, heteroaryloxyalkyl, hydroxyalkyl, amino, or mono- or disubstituted amino radical, wherein

20 the substituents are selected from the group consisting of alkyl, aryl, aralkyl, cycloalkyl, cycloalkylalkyl, heteroaryl, heteroaralkyl, heterocycloalkyl and heterocycloalkylalkyl radicals; or where said amino radical is disubstituted, said substituents along with

25 the nitrogen atom to which they are attached form a heterocycloalkyl or heteroaryl radical; or is represented by the formula



wherein R is a hydrogen, alkoxycarbonyl, aralkoxycarbonyl, alkylcarbonyl, cycloalkylcarbonyl, cycloalkylalkoxycarbonyl, cycloalkylalkanoyl, carboxyalkanoyl, alkanoyl, aralkanoyl, aroyl, 5 aryloxycarbonyl, aryloxycarbonylalkyl, aryloxyalkanoyl, heterocyclylcarbonyl, heterocyclyloxycarbonyl, heterocyclylalkanoyl, heterocyclylalkoxycarbonyl, heteroaralkanoyl, heteroaralkoxycarbonyl, heteroaryloxy-carbonyl, heteroaroyl, alkyl, alkenyl, alkynyl, 10 cycloalkyl, aryl, aralkyl, aryloxyalkyl, heteroaryloxyalkyl, hydroxyalkyl, aminocarbonyl, aminoalkanoyl, or mono- or disubstituted aminocarbonyl or mono- or disubstituted aminoalkanoyl radical, wherein the substituents are selected from the group consisting of 15 alkyl, aryl, aralkyl, cycloalkyl, cycloalkylalkyl, heteroaryl, heteroaralkyl, heterocycloalkyl and heterocycloalkyl radicals; or wherein said aminocarbonyl or aminoalkanoyl radicals are disubstituted, said substituents along with the nitrogen 20 atom to which they are attached form a heterocycloalkyl or heteroaryl radical;

R' is a radical as defined for R³ or R"SO₂-, wherein R" is a radical as defined for R³; or R and R' together with 25 the nitrogen to which they are attached form a heterocycloalkyl or heteroaryl radical;

R¹ is a hydrogen, -CO₂CH₃, -CH₂CO₂CH₃, -CO₂H, -CH₂CO₂H, -CH₂CH₂CONH₂, -CH₂CONH₂, -CONH₂, -CH₂C(O)NHCH₃, 30 -CH₂C(O)N(CH₃)₂, -CONHCH₃, -CONH(CH₃)₂, -CH₂SO₂NH₂, -CH₂CH₂SO₂NH₂, -CH₂S[O]CH₃, -CH₂S[O]₂CH₃, -C(CH₃)₂(SCH₃), -C(CH₃)₂(S[O]CH₃), -C(CH₃)₂(S[O]₂CH₃), alkyl, hydroxyalkyl, cyanoalkyl, haloalkyl, alkenyl, alkynyl, cycloalkyl, cycloalkylalkyl, alkylthioalkyl, aralkyl, 35 heteroaralkyl, aminoalkyl or mono- or disubstituted aminoalkyl radical, wherein said substituents are selected from the group consisting of alkyl, aryl,

aralkyl, cycloalkyl, cycloalkylalkyl, heteroaryl, heteroaralkyl, heterocycloalkyl and heterocycloalkylalkyl radicals; or where said aminoalkyl radical is disubstituted, said substituents along with the nitrogen atom to which they are attached, form a heterocycloalkyl or a heteroaryl radical; and

each of R^{1'} and R^{1''} are independently a radical as defined for R¹; or one of R^{1'} and R^{1''} together with R¹ and the carbon atoms to which R¹, R^{1'} and R^{1''} are attached, form a cycloalkyl radical.

2. The compound of Claim 1 or a pharmaceutically acceptable salt, prodrug or ester thereof, wherein

R² is an alkyl, aryl, cycloalkyl, cycloalkylalkyl or aralkyl radical, which radical is optionally substituted with a radical selected from the group consisting of alkyl, halo and -OR⁹, wherein R⁹ is a radical selected from the group consisting of hydrogen and alkyl;

R³ is a hydrogen, alkyl, haloalkyl, alkenyl, alkynyl, hydroxyalkyl, alkoxyalkyl, alkylthioalkyl, alkylsulfonylalkyl, cycloalkyl, cycloalkylalkyl, heterocycloalkyl, heteroaryl, heterocycloalkylalkyl, aryl, aralkyl, heteroaralkyl, aminoalkyl or mono- or disubstituted aminoalkyl radicals, wherein said substituents are selected from the group consisting of alkyl, aralkyl, cycloalkyl and cycloalkylalkyl radicals; or where said aminoalkyl radical is disubstituted, said substituents along with the nitrogen atom to which they are attached, form a heterocycloalkyl or a heteroaryl radical;

R⁴ is an alkyl, haloalkyl, alkenyl, alkynyl, hydroxyalkyl, alkoxyalkyl, cycloalkyl, cycloalkylalkyl,

250

heterocycloalkyl, heteroaryl, heterocycloalkylalkyl,
aryl, aralkyl, aralkenyl or heteroaralkyl radical;

R⁶ is a hydrogen or alkyl radical;

5

x is 1 or 2;

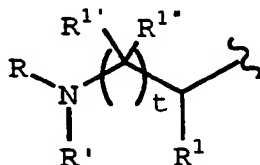
t is 0 or 1; and

10 Y is O or S; and

A is an alkoxy, alkenoxy, aralkoxy, alkyl, cycloalkyl,
cycloalkylalkoxy, cycloalkylalkyl, aralkyl, aryl,
aryloxy, heterocycloalkyl, heterocycloalkoxy,

15 heterocycloalkylalkyl, heterocycloalkylalkoxy,
heteroaralkyl, heteroaralkoxy, heteroaryloxy, heteroaryl,
hydroxyalkyl, amino, or mono- or disubstituted amino
radical, wherein the substituents are selected from the
group consisting of alkyl, aralkyl, heteroaryl,
20 heteroaralkyl, heterocycloalkyl and heterocycloalkylalkyl
radicals; or where said amino radical is disubstituted,
said substituents along with the nitrogen atom to which
they are attached form a heterocycloalkyl radical; or is
represented by the formula

25



wherein R is a hydrogen, alkoxycarbonyl,

aralkoxycarbonyl, alkylcarbonyl, carboxyalkanoyl,

30 alkanoyl, aralkanoyl, aroyl, heterocyclylcarbonyl,

heterocyclyloxy carbonyl, heterocyclylalkanoyl,

heterocyclylalkoxycarbonyl, heteroaralkanoyl,

heteroaralkoxycarbonyl, heteroaryloxy-carbonyl,

heteroaroyl, alkyl, cycloalkyl, aralkyl, hydroxyalkyl,

35 aminocarbonyl, aminoalkanoyl, or mono- or disubstituted

- aminocarbonyl or mono- or disubstituted aminoalkanoyl radical, wherein the substituents are selected from the group consisting of alkyl, aralkyl, heteroaryl, heteroaralkyl, heterocycloalkyl and heterocycloalkyl radicals; or wherein said aminocarbonyl or aminoalkanoyl radicals are disubstituted, said substituents along with the nitrogen atom to which they are attached form a heterocycloalkyl or heteroaryl radical;
- 10 R' is a hydrogen, alkyl or aralkyl radical or R"SO₂-, wherein R" is a radical as defined for R³; or R and R' together with the nitrogen to which they are attached form a heterocycloalkyl or heteroaryl radical;
- 15 R¹ is a hydrogen, -CO₂CH₃, -CH₂CO₂CH₃, -CO₂H, -CH₂CO₂H, -CH₂CH₂CONH₂, -CH₂CONH₂, -CONH₂, -CH₂C(O)NHCH₃, -CH₂C(O)N(CH₃)₂, -CONHCH₃, -CONH(CH₃)₂, -CH₂SO₂NH₂, -CH₂CH₂SO₂NH₂, -CH₂S[O]CH₃, -CH₂S[O]₂CH₃, -C(CH₃)₂(SCH₃), -C(CH₃)₂(S[O]CH₃), -C(CH₃)₂(S[O]₂CH₃), alkyl, hydroxyalkyl, cyanoalkyl, haloalkyl, alkenyl, alkynyl, cycloalkyl, cycloalkylalkyl, alkylthioalkyl, aralkyl, heteroaralkyl, aminoalkyl or mono- or disubstituted aminoalkyl radical, wherein said substituents are selected from the group consisting of alkyl, aralkyl, heteroaryl, heteroaralkyl, heterocycloalkyl and heterocycloalkylalkyl radicals; or where said aminoalkyl radical is disubstituted, said substituents along with the nitrogen atom to which they are attached, form a heterocycloalkyl or a heteroaryl radical; and
- 30 each of R¹' and R¹" are independently a radical as defined for R¹; or one of R¹' and R¹" together with R¹ and the carbon atoms to which R¹, R¹' and R¹" are attached, form a cycloalkyl radical.

35

3. The compound of Claim 2 or a pharmaceutically acceptable salt, prodrug or ester thereof, wherein

R² is an alkyl, aryl, cycloalkyl, cycloalkylalkyl or aralkyl radical, which radical is optionally substituted with a radical selected from the group consisting of
5 alkyl, halo and -OR⁹, wherein R⁹ is a radical selected from the group consisting of hydrogen and alkyl;

R³ is a hydrogen, alkyl, haloalkyl, alkenyl, alkynyl, hydroxyalkyl, alkoxyalkyl, alkylthioalkyl,
10 alkylsulfonylalkyl, cycloalkyl, cycloalkylalkyl, heterocycloalkyl, heteroaryl, heterocycloalkylalkyl, aryl, aralkyl, heteroaralkyl, aminoalkyl or mono- or dialkyl substituted aminoalkyl radical;

15 R⁴ is an alkyl, haloalkyl, alkenyl, alkynyl, hydroxyalkyl, alkoxyalkyl, cycloalkyl, cycloalkylalkyl, heterocycloalkyl, heteroaryl, heterocycloalkylalkyl, aryl, aralkyl, aralkenyl or heteroaralkyl radical;

20 R⁶ is a hydrogen or alkyl radical;

x is 1 or 2;

t is 0 or 1; and

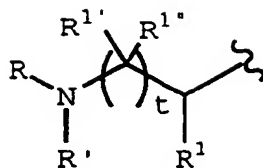
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Y is O or S; and

A is an alkoxy, alkenoxy, aralkoxy, alkyl, cycloalkyl, aryl, heterocycloalkyl, heterocycloalkoxy,
30 heterocycloalkylalkyl, heteroaralkoxy, heteroaryl, amino, or mono- or disubstituted amino radical, wherein the substituents are selected from the group consisting of alkyl and aralkyl radicals; or is represented by the formula

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wherein R is a hydrogen, alkoxycarbonyl, aralkoxycarbonyl, alkylcarbonyl, carboxyalkanoyl, alkanoyl, aroyl, heteroaroyl, alkyl, aralkyl, aminocarbonyl, aminoalkanoyl, or mono- or disubstituted aminocarbonyl or mono- or disubstituted aminoalkanoyl radical, wherein the substituents are selected from the group consisting of alkyl and aralkyl radicals;

R' is a hydrogen, alkyl or aralkyl radical or R"SO₂-, wherein R" is a radical as defined for R³; or R and R' together with the nitrogen to which they are attached form a heterocycloalkyl or heteroaryl radical;

R¹ is a hydrogen, -CO₂CH₃, -CH₂CO₂CH₃, -CO₂H, -CH₂CO₂H, -CH₂CH₂CONH₂, -CH₂CONH₂, -CONH₂, -CH₂C(O)NHCH₃, -CH₂C(O)N(CH₃)₂, -CONHCH₃, -CONH(CH₃)₂, -CH₂SO₂NH₂, -CH₂CH₂SO₂NH₂, -CH₂S[O]CH₃, -CH₂S[O]₂CH₃, -C(CH₃)₂(SCH₃), -C(CH₃)₂(S[O]CH₃), -C(CH₃)₂(S[O]₂CH₃), alkyl, hydroxyalkyl, cyanoalkyl, haloalkyl, alkenyl, alkynyl, cycloalkyl, cycloalkylalkyl, alkylthioalkyl, aralkyl, heteroaralkyl, aminoalkyl or mono- or disubstituted aminoalkyl radical, wherein said substituents are selected from the group consisting of alkyl and aralkyl radicals; and

R^{1'} is a hydrogen, alkyl or aralkyl; and R^{1''} is a hydrogen, alkyl, -CO₂CH₃ or -CONH₂; or one of R^{1'} and R^{1''} together with R¹ and the carbon atoms to which R¹, R^{1'} and R^{1''} are attached, form a cycloalkyl radical.

4. The compound of Claim 3 or a pharmaceutically acceptable salt, prodrug or ester thereof, wherein

R² is an alkyl, cycloalkylalkyl or aralkyl radical, which radical is optionally substituted with a radical selected from the group consisting of alkyl, halo and -OR⁹,
 5 wherein R⁹ is a radical selected from the group consisting of hydrogen and alkyl;

R³ is a hydrogen, alkyl, alkenyl, alkynyl, hydroxyalkyl, alkoxyalkyl, alkylthioalkyl, alkylsulfonylalkyl,
 10 cycloalkyl, cycloalkylalkyl, heterocycloalkylalkyl, aryl, aralkyl, heteroaralkyl, aminoalkyl or mono- or dialkyl substituted aminoalkyl radical;

R⁴ is an alkyl, haloalkyl, alkenyl, alkynyl, hydroxyalkyl, alkoxyalkyl, cycloalkyl, cycloalkylalkyl, heterocycloalkyl, heteroaryl, heterocycloalkylalkyl, aryl, aralkyl, aralkenyl or heteroaralkyl radical;

R⁶ is a hydrogen or alkyl radical;

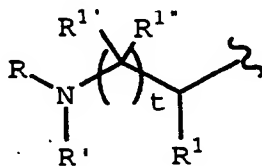
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x is 1 or 2;

t is 0 or 1; and

25 Y is O or S; and

A is an alkoxy, alkenoxy, aralkoxy, alkyl, cycloalkyl, aryl, heterocycloalkyl, heterocycloalkoxy, heterocycloalkylalkyl, heteroaralkoxy, heteroaryl, amino, or mono- or disubstituted amino radical, wherein the
 30 substituents are selected from the group consisting of alkyl and aralkyl radicals; or is represented by the formula



- wherein R is a hydrogen, alkoxycarbonyl, aralkoxycarbonyl, alkylcarbonyl, carboxyalkanoyl, alkanoyl, aroyl, heteroaroyl, alkyl, aralkyl, aminocarbonyl, aminoalkanoyl, or mono- or disubstituted aminocarbonyl or mono- or disubstituted aminoalkanoyl radical, wherein the substituents are selected from the group consisting of alkyl and aralkyl radicals;
- 10 R' is a hydrogen, alkyl or aralkyl radical or R"SO₂-, wherein R" is a radical as defined for R³; or R and R' together with the nitrogen to which they are attached form a heterocycloalkyl or heteroaryl radical;
- 15 R¹ is a hydrogen, -CO₂H, -CH₂CO₂H, -CH₂CH₂CONH₂, -CH₂CONH₂, -CONH₂, -CH₂C(O)NHCH₃, -CH₂C(O)N(CH₃)₂, -CONHCH₃, -CONH(CH₃)₂, -CH₂SO₂NH₂, -CH₂CH₂SO₂NH₂, alkyl, hydroxyalkyl, cyanoalkyl, alkynyl, cycloalkylalkyl, alkylthioalkyl, aralkyl or heteroaralkyl radical; and
- 20 R¹' is a hydrogen, alkyl or aralkyl; and R¹" is a hydrogen, alkyl, -CO₂CH₃ or -CONH₂; or one of R¹' and R¹" together with R¹ and the carbon atoms to which R¹, R¹' and R¹" are attached, form a cycloalkyl radical;
- 25 with the proviso that alkyl, alone or in combination, is a straight-chain or branched-chain hydrocarbon radical containing from one to eight carbon atoms; alkenyl, alone or in combination, is a straight-chain or branched-chain hydrocarbon radical having at least one double bond and
- 30 containing from two to eight carbon atoms; alkynyl, alone or in combination, is a straight-chain or branched-chain hydrocarbon radical having at least one triple bond and containing from two to ten carbon atoms; and cycloalkyl,
- 35 alone or in combination, is a hydrocarbon ring containing from three to eight carbon atoms.

5. The compound of Claim 4 or a pharmaceutically acceptable salt, prodrug or ester thereof, wherein

5 R² is an alkyl, cycloalkylalkyl or aralkyl radical, which radical is optionally substituted with a radical selected from the group consisting of alkyl, halo and -OR⁹, wherein R⁹ is a radical selected from the group consisting of hydrogen and alkyl;

10 R³ is a hydrogen, alkyl, alkenyl, alkynyl, hydroxyalkyl, alkoxyalkyl, alkylthioalkyl, alkylsulfonylalkyl, cycloalkyl, cycloalkylalkyl, heterocycloalkylalkyl, aryl, aralkyl, heteroaralkyl, aminoalkyl or mono- or dialkyl substituted aminoalkyl radical;

15 R⁴ is an alkyl, haloalkyl, alkenyl, alkynyl, hydroxyalkyl, alkoxyalkyl, cycloalkyl, cycloalkylalkyl, heterocycloalkyl, heteroaryl, heterocycloalkylalkyl, aryl, aralkyl, aralkenyl or heteroaralkyl radical;

20 R⁶ is a hydrogen or alkyl radical;

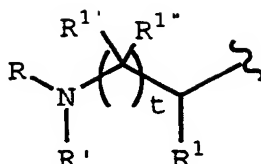
x is 1 or 2;

25 t is 0 or 1; and

Y is O or S; and

30 A is an alkoxy, alkenoxy, aralkoxy, alkyl, cycloalkyl, aryl, heterocycloalkyl, heterocycloalkoxy, heterocycloalkylalkyl, heteroaralkoxy, heteroaryl, amino, or mono- or disubstituted amino radical, wherein the substituents are selected from the group consisting of alkyl and aralkyl radicals; or is represented by the
35 formula

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wherein R is a hydrogen, alkoxycarbonyl, aralkoxycarbonyl, alkylcarbonyl, carboxyalkanoyl, alkanoyl, aroyl, heteroaroyl, alkyl, aralkyl, aminocarbonyl, aminoalkanoyl, or mono- or disubstituted aminocarbonyl or mono- or disubstituted aminoalkanoyl radical, wherein the substituents are selected from the group consisting of alkyl and aralkyl radicals;

R' is a hydrogen, alkyl or aralkyl radical or R"SO₂-, wherein R" is a radical as defined for R³; or R and R' together with the nitrogen to which they are attached form a heterocycloalkyl or heteroaryl radical;

R¹ is a hydrogen, -CO₂H, -CH₂CO₂H, -CH₂CH₂CONH₂, -CH₂CONH₂, -CONH₂, -CH₂C(O)NHCH₃, -CH₂C(O)N(CH₃)₂, -CONHCH₃, -CONH(CH₃)₂, -CH₂SO₂NH₂, -CH₂CH₂SO₂NH₂, alkyl, hydroxyalkyl, cyanoalkyl, alkynyl, cycloalkylalkyl, alkylthioalkyl, aralkyl or heteroaralkyl radical; and

R¹' is a hydrogen, alkyl or aralkyl; and R¹" is a hydrogen, alkyl, -CO₂CH₃ or -CONH₂; or one of R¹' and R¹" together with R¹ and the carbon atoms to which R¹, R¹' and R¹" are attached, form a cycloalkyl radical;

with the proviso that alkyl, alone or in combination, is a straight-chain or branched-chain hydrocarbon radical containing from one to five carbon atoms; alkenyl, alone or in combination, is a straight-chain or branched-chain hydrocarbon radical having at least one double bond and containing from two to five carbon atoms; alkynyl, alone or in combination, is a straight-chain or branched-chain hydrocarbon radical having at least one triple bond and

containing from two to five carbon atoms; and cycloalkyl, alone or in combination, is a hydrocarbon ring containing from three to eight carbon atoms; and

- 5 with the proviso that when R² is cycloalkylalkyl and t is 0, R' is a group other than alkoxycarbonyl.

6. The compound of Claim 5 or a pharmaceutically acceptable salt, prodrug or ester thereof, wherein

10

R² is butyl, cyclohexylmethyl, benzyl, 4-fluorobenzyl or naphthylmethyl;

15 R³ is methyl, ethyl, propyl, butyl, pentyl, hexyl, isobutyl, iso-amyl, 3-methoxypropyl, 3-methylthiopropyl, 4-methylthiobutyl, 4-methylsulfonylbutyl, 2-dimethylaminoethyl, 2-(1-morpholino)ethyl, 4-hydroxybutyl, allyl, propargyl, cyclohexylmethyl, cyclopropylmethyl, phenyl, benzyl, 4-fluorobenzyl, 4-methoxybenzyl, 1-phenylethyl, 2-phenylethyl,
20 naphthylmethyl, 3-pyridylmethyl or 4-pyridylmethyl;

R⁴ is methyl, ethyl, propyl, butyl, ethenyl, chloromethyl, cyclopropyl, cyclobutyl, cyclopentyl, cyclohexyl, phenyl, naphthyl, chlorophenyl, fluorophenyl,
25 hydroxyphenyl, methylphenyl, methoxyphenyl, ethoxyphenyl, methylthiophenyl, methylsulfoxyphenyl, methylsulfonylphenyl, acetamidophenyl, methoxycarbonylphenyl, dimethylaminophenyl, nitrophenyl, trifluoromethylphenyl, benzyl, 2-phenylethenyl or
30 thienyl;

R⁶ is hydrogen;

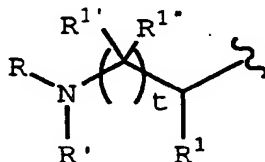
35 x is 2;

t is 0 or 1; and

Y is O; and

A is methyl, cyclohexyl, cyclopentyl, cycloheptyl,
 5 1,2,3,4-tetrahydronaphthyl, naphthyl, quinolinyll,
 indolyl, pyridyl, methylpyridyl, furanyl, thiophenyl,
 oxazolyl, thiazolyl, phenyl, methylphenyl, ethylphenyl,
 dimethylphenyl, iso-propylphenyl, chlorophenyl,
 hydroxyphenyl, methoxyphenyl, methylsulfonylphenyl,
 10 methylsulfonylmethylphenyl, carboxyphenyl,
 aminocarbonylphenyl, methylhydroxyphenyl,
 methylnitrophenyl, methylaminophenyl, methyl-N,N-
 dimethylaminophenyl, t-butoxy, benzyloxy, pyridylmethoxy,
 3-propenoxy, hydroxypyridylmethoxy, aminopyridylmethoxy,
 15 pyrimidinylmethoxy, N-oxo-pyrimidinylmethoxy,
 thiazolylmethoxy, tetrahydrothiophenoxy, 1,1-
 dioxotetrahydrothiophenoxy, tetrahydrofuranoxo,
 methylamino, benzylamino or isopropylamino; or is
 represented by the formula

20



wherein R is hydrogen, acetyl, phenoxyacetyl,
 methoxyacetyl, naphthaloxyacetyl, succinoyl, 2-
 25 methylpropionoyl, 2-hydroxypropionoyl, t-butoxycarbonyl,
 benzyloxycarbonyl, methoxybenzyloxycarbonyl,
 aminocarbonyl, quinolinylcarbonyl, N-methylglycinyl or
 N,N-dimethylglycinyl;

30 R¹ is hydrogen, benzyl or methyl; or R and R¹ together
 with the nitrogen to which they are attached form
 pyrrolyl;

R¹ is hydrogen, -CO₂H, -CH₂CO₂H, -CH₂CH₂CONH₂, -CH₂CONH₂,
 35 -CONH₂, -CH₂C(O)NHCH₃, -CH₂C(O)N(CH₃)₂, -CONHCH₃,

-CONH(CH₃)₂, -CH₂SO₂NH₂, -CH₂CH₂SO₂NH₂, methyl, ethyl, propyl, isopropyl, butyl, isobutyl, sec-butyl, tert-butyl, 3-methylbutyl, cyclohexylmethyl, benzyl, hydroxybenzyl, imidazolyl, imidazolymethyl, cyanomethyl, methylthiomethyl, propargyl or hydroxyethyl; and

R^{1'} is hydrogen, methyl, ethyl, propyl, isopropyl, butyl, isobutyl, benzyl, phenylethyl, phenylpropyl, phenylbutyl or 4,4-diphenylbutyl; and R^{1''} is hydrogen, methyl, -CO₂CH₃ or -CONH₂; or one of R^{1'} and R^{1''} together with R¹ and the carbon atoms to which R¹, R^{1'} and R^{1''} are attached, form cyclobutyl, cyclopentyl or cyclohexyl;

with the proviso that when R² is cyclohexylmethyl and t is 0, R' is a group other than t-butoxycarbonyl.

7. The compound of Claim 1 which is:

Phenylmethyl[2R-hydroxy-3-[(3-methylbutyl) (methylsulfonyl) amino]-1S-(phenylmethyl)propyl]carbamate;

Phenylmethyl[2R-hydroxy-3-[(3-methylbutyl) (phenylsulfonyl) amino]-1S-(phenylmethyl)propyl]carbamate;

N1-[2R-hydroxy-3-[(3-methylbutyl) (methylsulfonyl) amino]-1S-(phenylmethyl)propyl]-2S-[(2-quinolinylcarbonyl) amino] butanediamide;

N1-[2R-hydroxy-3-[(3-methylbutyl) (methylsulfonyl) amino]-1S-(phenylmethyl)propyl]-2S-[(phenylmethyloxycarbonyl) amino] butanediamide;

N1-[2R-hydroxy-3-[(3-methylbutyl) (phenylsulfonyl) amino]-1S-(phenylmethyl)propyl]-2S-[(2-quinolinylcarbonyl) amino] butanediamide;

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- N1-[2R-hydroxy-3-[(3-methylbutyl)(phenylsulfonyl)amino]-1S-(phenylmethyl)propyl]-2S-[(phenylmethyloxycarbonyl)amino]butanediamide;
- 5 2S-[[(dimethylamino)acetyl]amino]-N-[2R-hydroxy-3-[(3-methyl- butyl)(phenylsulfonyl)amino]-1S-(phenylmethyl)propyl]-3,3-dimethylbutaneamide;
- 10 2S-[[(methylamino)acetyl]amino]-N-[2R-hydroxy-3-[(3-methyl- butyl)(phenylsulfonyl)amino]-1S-(phenylmethyl)propyl]-3,3-dimethylbutaneamide;
- 15 N1-[2R-hydroxy-3-[(3-methylbutyl)(phenyl-sulfonyl)amino]-N4-methyl-1S-(phenylmethyl)propyl]-2S-[(2-quinolinylcarbonyl)amino]butanediamide;
- 20 [3-[[2-hydroxy-3-[N-(3-methylbutyl)-N-(phenylsufonyl)amino]-1-(phenylmethyl)propyl]amino]-2-methyl-3-oxopropyl]-, (4-methoxyphenyl)methyl ester, [1S-[1R*(S*),2S*]]-;
- 25 Carbamic acid, [2R-hydroxy-3-[(4-hydroxyphenylsulfonyl)(2-methylpropyl)amino]-1S-(phenylmethyl)propyl-, 3(S)-1,1-dioxotetrahydrothiophen-3-yl-ester;
- 30 Carbamic acid, [2R-hydroxy-3-[(4-methoxyphenylsulfonyl)(2-methylpropyl)amino]-1S-(phenylmethyl)propyl-, 3(S)-1,1-dioxotetrahydrothiophen-3-yl-ester;
- 35 Carbamic acid, [2R-hydroxy-3-[(4-hydroxyphenylsulfonyl)(2-methylpropyl)amino]-1S-(phenylmethyl)propyl-, 3-S-tetrahydrothiophen-3-yl-ester;

Carbamic acid, [2R-hydroxy-3-[(4-hydroxyphenylsulfonyl)(2-methylpropyl)amino]-1S-(phenylmethyl)propyl-, 3-S-tetrahydrofuran-3-yl-ester;

- 5 Carbamic acid, [2R-hydroxy-3-[(4-methoxyphenylsulfonyl)(2-methylpropyl)amino]-1S-(phenylmethyl)propyl-, 3-S-tetrahydrofuran-3-yl-ester;

- 10 Carbamic acid, [2R-hydroxy-3-[[4-methoxyphenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-, 5-(thiazolyl)methyl ester;

- 15 Carbamic acid, [2R-hydroxy-3-[[4-hydroxyphenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-, 5-(thiazolyl)methyl ester;

- 20 Benzamide, N-[2R-hydroxy-3-[[4-hydroxyphenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-2-methyl;

Carbamic acid, [2R-hydroxy-3-[[4-methoxyphenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-, 3-(6-aminopyridyl)methyl ester;

- 25 Carbamic acid, [2R-hydroxy-3-[[4-hydroxyphenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-, 3-(6-aminopyridyl)methyl ester;

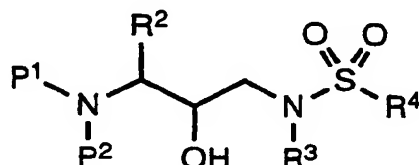
- 30 Carbamic acid, [2R-hydroxy-3-[[4-methoxyphenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-, 3-(6-hydroxypyridyl)methyl ester;

- 35 Carbamic acid, [2R-hydroxy-3-[[4-hydroxyphenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-, 5-pyrimidylmethyl ester; or

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Benzamide, N-[2R-hydroxy-3-[[(4-methoxyphenyl) sulfonyl]
(2-methylpropyl) amino]-1S-(phenylmethyl)propyl]-2-methyl.

8. A compound represented by the formula:



or a pharmaceutically acceptable salt, prodrug or ester thereof, wherein

10

each of P¹ and P² independently represent hydrogen, alkoxy carbonyl, aralkoxy carbonyl, alkyl carbonyl, cycloalkyl carbonyl, cycloalkyl alkoxy carbonyl, cycloalkyl alkanoyl, alkanoyl, aralkanoyl, aroyl, aryloxy carbonyl, aryloxy carbonyl alkyl, aryloxy alkanoyl, heterocyclyl carbonyl, heterocyclyloxy carbonyl, heterocyclyl alkanoyl, heterocyclyl alkoxy carbonyl, heteroaralkanoyl, heteroaralkoxy carbonyl, heteroaryloxy carbonyl, heteroaroyl, alkyl, alkenyl, cycloalkyl, aryl, aralkyl, aryloxy alkyl, heteroaryloxy alkyl, hydroxy alkyl, aminocarbonyl, amino alkanoyl, or mono- or disubstituted aminocarbonyl or mono- or disubstituted amino alkanoyl radical, wherein the substituents are selected from the group consisting of alkyl, aryl, aralkyl, cycloalkyl, cycloalkyl alkyl, heteroaryl, heteroaralkyl, heterocycloalkyl and heterocycloalkyl radicals; or where said amino alkanoyl radical is disubstituted, said substituents along with the nitrogen atom to which they are attached form a heterocycloalkyl or heteroaryl radical;

30

R² is an alkyl, aryl, cycloalkyl, cycloalkyl alkyl or aralkyl radical, which radicals are optionally substituted with a group selected from alkyl and halogen

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radicals, nitro, cyano, CF_3 , $-\text{OR}^9$, $-\text{SR}^9$, wherein R^9 is a hydrogen or alkyl radical;

R^3 is a hydrogen, alkyl, haloalkyl, alkenyl, alkynyl,
5 hydroxyalkyl, alkoxyalkyl, cycloalkyl, cycloalkylalkyl,
heterocycloalkyl, heteroaryl, heterocycloalkylalkyl,
aryl, aralkyl, heteroaralkyl, aminoalkyl or mono- or
disubstituted aminoalkyl radical, wherein said
substituents are selected from the group consisting of
10 alkyl, aryl, aralkyl, cycloalkyl, cycloalkylalkyl,
heteroaryl, heteroaralkyl, heterocycloalkyl and
heterocycloalkylalkyl radicals; or where the aminoalkyl
radical is disubstituted, said substituents along with
the nitrogen atom to which they are attached, form a
15 heterocycloalkyl or a heteroaryl radical; and

R^4 is a radical as defined by R^3 except for hydrogen.

9. The compound of Claim 8, wherein each of P^1 and
20 P^2 independently represent a hydrogen, alkoxycarbonyl,
aralkyloxycarbonyl, heteroaralkyloxycarbonyl, aroyl,
heteroaroyl, alkanoyl or cycloalkanoyl radical;

R^2 is a cycloalkylalkyl, aralkyl or alkyl radical;
25

R^3 is an alkyl, cycloalkyl or cycloalkylalkyl radical;
and

R^4 is an aryl, alkyl, heteroaryl or aryl radical.
30

10. The compound of Claim 9, wherein P^1 and P^2
independently represent 3-pyridylmethyloxycarbonyl, 3-
pyridylmethyloxycarbonyl N-oxide, 4-
pyridylmethyloxycarbonyl, 4-pyridylmethyloxycarbonyl N-
35 oxide, 5-pyrimidylmethyloxycarbonyl, tert-
butyloxycarbonyl, allyloxycarbonyl, 2-propyloxycarbonyl,
benzyloxycarbonyl, cycloheptylcarbonyl,

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cyclohexylcarbonyl, cyclopentylcarbonyl, benzoyl, 4-pyridylcarbonyl, 2-methylbenzoyl, 3-methylbenzoyl, 4-methylbenzoyl, 2-chlorobenzoyl, 2-ethylbenzoyl, 2,6-dimethylbenzoyl, 2,3-dimethylbenzoyl, 2,4-dimethylbenzoyl or 2,5-dimethylbenzoyl;

R² is benzyl, cyclohexylmethyl, 2-naphthylmethyl, para-fluorobenzyl, para-methoxybenzyl, isobutyl or n-butyl;

10 R³ is isobutyl, isoamyl, cyclohexyl, cyclohexylmethyl, n-butyl or n-propyl; and

15 R⁴ is phenyl, para-methoxyphenyl, para-cyanophenyl, para-chlorophenyl, para-hydroxyphenyl, para-nitrophenyl, para-fluorophenyl, 2-naphthyl, 3-pyridyl, 3-pyridyl N-oxide, 4-pyridyl or 4-pyridyl N-oxide;

with the proviso that when R² is cyclohexylmethyl, each of P¹ and P² independently represent a group other than
20 tert-butyloxycarbonyl.

11. A compound of Claim 8 which is:

Phenylmethyl[2R-hydroxy-3-[(2-methylpropyl)
25 (phenylsulfonyl)amino]-1S-(phenylmethyl)propyl]carbamate;

Phenylmethyl[2R-hydroxy-3-[(2-methylpropyl)(4-methoxyphenylsulfonyl)amino]-1S-(phenylmethyl)
30 propyl]carbamate;

Phenylmethyl[2R-hydroxy-3-[(2-methylpropyl)(4-fluorophenylsulfonyl)amino]-1S-(phenylmethyl)
propyl]carbamate;

35 Phenylmethyl[2R-hydroxy-3-[(2-methylpropyl)(4-nitrophenylsulfonyl)amino]-1S-(phenylmethyl)propyl]carbamate;

Phenylmethyl[2R-hydroxy-3-[(2-methylpropyl)(4-chlorophenylsulfonyl)amino]-1S-(phenylmethyl)propyl]carbamate;

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Phenylmethyl[2R-hydroxy-3-[(2-methylpropyl)(4-acetamidophenylsulfonyl)amino]-1S-(phenylmethyl)propyl]carbamate;

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Phenylmethyl[2R-hydroxy-3-[(2-methylpropyl)(4-aminophenylsulfonyl)amino]-1S-(phenylmethyl)propyl]carbamate;

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Phenylmethyl[2R-hydroxy-3-[(3-methylbutyl)(4-methoxyphenylsulfonyl)amino]-1S-(phenylmethyl)propyl]carbamate;

20

Phenylmethyl[2R-hydroxy-3-[(3-methylbutyl)(4-fluorophenylsulfonyl)amino]-1S-(phenylmethyl)propyl]carbamate;

Phenylmethyl[2R-hydroxy-3-[(3-methylbutyl)(4-nitrophenylsulfonyl)amino]-1S-(phenylmethyl)propyl]carbamate;

25

Phenylmethyl[2R-hydroxy-3-[(3-methylbutyl)(4-chlorophenylsulfonyl)amino]-1S-(phenylmethyl)propyl]carbamate;

30

Phenylmethyl[2R-hydroxy-3-[(2-methylpropyl)(4-methoxyphenylsulfonyl)amino]-1S-(4-fluorophenylmethyl)propyl]carbamate;

Phenylmethyl[2R-hydroxy-3-[(2-methylpropyl)(4-fluorophenylsulfonyl)amino]-1S-(4-fluorophenylmethyl)propyl]carbamate;

35

Phenylmethyl[2R-hydroxy-3-[(butyl)(phenylsulfonyl)amino]-1S-(phenylmethyl)propyl]carbamate;

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Phenylmethyl[2R-hydroxy-3-[(cyclohexylmethyl)(phenylsulfonyl)amino]-1S-(phenylmethyl)propyl]carbamate;

5 Phenylmethyl[2R-hydroxy-3-[(cyclohexyl)(phenylsulfonyl)amino]-1S-(phenylmethyl)propyl]carbamate;

Phenylmethyl[2R-hydroxy-3-[(propyl)(phenylsulfonyl)amino]-1S-(phenylmethyl)propyl]carbamate;

10 Pentanamide, 2S-[[[(dimethylamino)acetyl]amino]-N-2R-hydroxy-3-[(3-methylpropyl)(4-methoxyphenylsulfonyl)amino]-1S-(phenylmethyl)propyl]-3S-methyl;

15 Pentanamide, 2S-[[[(methylamino)acetyl]amino]-N-2R-hydroxy-3-[(4-methylbutyl)(phenylsulfonyl)amino]-1S-(phenylmethyl)propyl]-3S-methyl;

20 Pentanamide, 2S-[[[(dimethylamino)acetyl]amino]-N-2R-hydroxy-3-[(4-methylbutyl)(phenylsulfonyl)amino]-1S-(phenylmethyl)propyl]-3S-methyl;

[2R-hydroxy-3-[[[(4-methoxyphenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]amine;

25 2R-hydroxy-3-[(2-methylpropyl)(4-hydroxyphenyl)sulfonyl]amino-1S-(phenylmethyl)propylamine;

30 [2R-hydroxy-3-[(phenylsulfonyl)(3-methylbutyl)amino]-1S-(phenylmethyl)propylamine;

[2R-hydroxy-3-[(phenylsulfonyl)(2-methylpropyl)amino]-1S-(phenylmethyl)propylamine;

35 [2R-hydroxy-3-[(phenylsulfonyl)(cyclohexylmethyl)amino]-1S-(phenylmethyl)propylamine;

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[2R-hydroxy-3-[(phenylsulfonyl)(cyclohexyl)amino]-1S-(phenylmethyl)propylamine;

4-Pyridinecarboxamide, N-[2R-hydroxy-3-[[4-methoxyphenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl];

Benzamide, N-[2R-hydroxy-3-[[4-methoxyphenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-2,6-dimethyl;

Benzamide, N-[2R-hydroxy-3-[[4-methoxyphenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-2-methyl;

Benzamide, N-[2R-hydroxy-3-[[4-methoxyphenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-2-ethyl;

Benzamide, N-[2R-hydroxy-3-[[4-methoxyphenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-2-chloro;

Carbamic acid, [2R-hydroxy-3-[[4-methoxyphenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-, 3-pyridylmethyl ester;

Carbamic acid, [2R-hydroxy-3-[[4-methoxyphenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-, 3-pyridylmethyl ester, N-oxide;

Carbamic acid, [2R-hydroxy-3-[[phenylsulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-, 3-pyridylmethyl ester;

Carbamic acid, [2R-hydroxy-3-[[4-methoxyphenyl)sulfonyl](2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-, 4-pyridylmethyl ester;

Carbamic acid, [2R-hydroxy-3-[[[4-methoxyphenyl)sulfonyl]
(2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-, 4-
pyridylmethyl ester, N-oxide;

- 5 Carbamic acid, [2R-hydroxy-3-[[[4-chlorophenyl)sulfonyl]
(2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-, 3-
pyridylmethyl ester;

- 10 Carbamic acid, [2R-hydroxy-3-[[[4-nitrophenyl)sulfonyl]
(2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-, 3-
pyridylmethyl ester;

- 15 Carbamic acid, [2R-hydroxy-3-[[[4-fluorophenyl)sulfonyl]
(2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-, 3-
pyridylmethyl ester;

- 20 Carbamic acid, [2R-hydroxy-3-[[[4-hydroxyphenyl)sulfonyl]
(2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-, 3-
pyridylmethyl ester; or

- Carbamic acid, [2R-hydroxy-3-[[[4-methoxyphenyl)sulfonyl]
(2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-, 5-
pyrimidylmethyl ester.

- 25 12. A compound of Claim 8 which is:

- 30 Carbamic acid, [2R-hydroxy-3-[[[4-methoxyphenyl)sulfonyl]
(methylpropyl)amino]-1S-(phenylmethyl)propyl]-, 5-
thiazolylmethyl ester;

- Carbamic acid, [2R-hydroxy-3-[[[4-hydroxyphenyl)sulfonyl]
(2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-, 5-
thiazolylmethyl ester;

- 35 Carbamic acid, [2R-hydroxy-3-[[[4-methoxyphenyl)sulfonyl]
(2-methylpropyl)amino]-1S-(phenylmethyl)propyl]-, 3-
furanylmethyl ester;

- Benzamide, N-[2R-hydroxy-3-[[(4-methoxyphenyl) sulfonyl] (2-methylpropyl) amino]-1S-(phenylmethyl)propyl]-3-hydroxy-2-methyl;
- 5 2R-hydroxy-3-[[(4-aminophenyl) sulfonyl] (2-methylpropyl) amino]-1S-(phenylmethyl)propylamine;
- 10 Carbamic acid, 2R-hydroxy-3-[[(4-aminophenyl) sulfonyl] (2-methylpropyl) amino]-1S-(phenylmethyl)propyl-, 3-furanylmethyl ester;
- 15 Carbamic acid, 2R-hydroxy-3-[[(4-aminophenyl) sulfonyl] (2-methylpropyl) amino]-1S-(phenylmethyl)propyl-, 5-thiazolylmethyl ester;
- 20 Benzamide, N-[2R-hydroxy-3-[[(4-aminophenyl) sulfonyl] (2-methylpropyl) amino]-1S-(phenylmethyl)propyl]-2-methyl;
- 25 Benzamide, N-[2R-hydroxy-3-[[(4-aminophenyl) sulfonyl] (2-methylpropyl) amino]-1S-(phenylmethyl)propyl]-3-hydroxy-2-methyl;
- Carbamic acid, 2R-hydroxy-3-[[(2-aminobenzothiazol-6-yl) sulfonyl] (2-methylpropyl) amino]-1S-(phenylmethyl)propyl-, phenylmethyl ester;
- 30 Carbamic acid, 2R-hydroxy-3-[[(benzothiazol-6-yl) sulfonyl] (2-methylpropyl) amino]-1S-(phenylmethyl)propyl-, phenylmethyl ester;
- 2R-hydroxy-3-[[(3-aminophenyl) sulfonyl] (2-methylpropyl) amino]-1S-(phenylmethyl)propylamine;
- 35 Carbamic acid, 2R-hydroxy-3-[[(3-aminophenyl) sulfonyl] (2-methylpropyl) amino]-1S-(phenylmethyl)propyl-, 5-thiazolylmethyl ester;

Benzamide, N-[2R-hydroxy-3-[[(3-aminophenyl) sulfonyl] (2-methylpropyl) amino]-1S-(phenylmethyl)propyl]-3-hydroxy-2-methyl;

5

Carbamic acid, 2R-hydroxy-3-[[(2-amino benzothiazol-5-yl) sulfonyl] (2-methylpropyl) amino]-1S-(phenylmethyl)propyl-, phenylmethyl ester;

10 Carbamic acid, 2R-hydroxy-3-[[(2-aminobenzothiazol-7-yl) sulfonyl] (2-methylpropyl) amino]-1S-(phenylmethyl)propyl-, phenylmethyl ester;

15 2R-hydroxy-3-[[(2,3-dihydrobenzofuran-5-yl) sulfonyl] (2-methylpropyl) amino]-1S-(phenylmethyl) propylamine;

Carbamic acid, [2R-hydroxy-3-[[(2,3-dihydrobenzofuran-5-yl) sulfonyl] (2-methylpropyl) amino]-1S-(phenylmethyl) propyl-, 3-pyridylmethyl ester;

20

Carbamic acid, [2R-hydroxy-3-[[(2,3-dihydrobenzofuran-5-yl) sulfonyl] (2-methylpropyl) amino]-1S-(phenylmethyl) propyl-, 5-thiazolylmethyl ester;

25 Benzamide, N-[2R-hydroxy-3-[[(2,3-dihydrobenzofuran-5-yl) sulfonyl] (2-methylpropyl) amino]-1S-(phenylmethyl)propyl]-3-amino-2-methyl-;

30 2R-hydroxy-3-[[(1,3-benzodioxol-5-yl) sulfonyl] (2-methylpropyl) amino]-1S-(phenylmethyl) propylamine;

Carbamic acid, 2R-hydroxy-3-[[(1,3-benzodioxol-5-yl) sulfonyl] (2-methylpropyl) amino]-1S-(phenylmethyl)propyl-, 3-pyridylmethyl ester;

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Carbamic acid, 2R-hydroxy-3-[[[(1,3-benzodioxol-5-yl) sulfonyl] (2-methylpropyl) amino]-1S-(phenylmethyl)propyl-, 5-thiazolylmethyl ester;

- 5 Benzamide, N-[2R-hydroxy-3-[[[(1,3-benzodioxol-5-yl) sulfonyl] (2-methylpropyl) amino]-1S-(phenylmethyl)propyl]-3-amino-2-methyl;

- 10 Benzamide, N-[2R-hydroxy-3-[[[(1,3-benzodioxol-5-yl) sulfonyl] (2-methylpropyl) amino]-1S-(phenylmethyl)propyl]-4-hydroxy-2-methyl;

- 15 Benzamide, N-[2R-hydroxy-3-[[[(1,3-benzodioxol-5-yl) sulfonyl] (2-methylpropyl) amino]-1S-(phenylmethyl)propyl]-3-hydroxy-2-methyl;

- 20 N-[2R-hydroxy-3-[[[(4-methoxyphenyl) sulfonyl] (2-methylpropyl) amino]-1S-(phenylmethyl)propyl]-(2,6-dimethylphenoxy)acetamide;

N-[2R-hydroxy-3-[[[(4-methoxyphenyl) sulfonyl] (2-methylpropyl) amino]-1S-(phenylmethyl)propyl]-(2-methylphenoxy)acetamide;

- 25 N-[2R-hydroxy-3-[[[(4-methoxyphenyl) sulfonyl] (2-methylpropyl) amino]-1S-(phenylmethyl)propyl]-2-(2,6-dimethylphenylamino)acetamide; or

- 30 N-[2R-hydroxy-3-[[[(4-methoxyphenyl) sulfonyl] (2-methylpropyl) amino]-1S-(phenylmethyl)propyl]-2-amino-benzothiazole-6-carboxamide.

13. A pharmaceutical composition comprising a compound of Claim 1 and a pharmaceutically acceptable
35 carrier.

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14. A pharmaceutical composition comprising a compound of Claim 8 and a pharmaceutically acceptable carrier.

5 15. Method of inhibiting a retroviral protease comprising administering an effective amount of a compound of Claim 1.

10 16. Method of inhibiting a retroviral protease comprising administering an effective amount of a compound of Claim 8.

15 17. Method of treating a retroviral infection comprising administering an effective amount of a composition of Claim 13.

20 18. Method of treating a retroviral infection comprising administering an effective amount of a composition of Claim 14.

25 19. Method of preventing replication of a retrovirus comprising administering an effective amount of a compound of Claim 1.

30 20. Method of preventing replication of a retrovirus comprising administering an effective amount of a compound of Claim 8.

INTERNATIONAL SEARCH REPORT

Intern al Application No
PCT/US 94/09139

A. CLASSIFICATION OF SUBJECT MATTER

IPC 6 C07C311/29 C07D213/30 C07C317/14 C07C311/18 C07D307/79
C07K5/062 A61K31/18 A61K31/44

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 C07C C07D C07K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP,A,0 264 795 (MERCK PATENT GMBH) 27 April 1988 cited in the application see column 1 - column 2; example 6 ---	1-6,8,13 ,14
X	EP,A,0 468 641 (SHIONOGI & CO) 29 January 1992 cited in the application see page 3; table 6 ---	1-6,8,13 ,14
P,X	WO,A,94 04492 (SEARLE, ET AL.) 3 March 1994 see the whole document -----	1-20

☐ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

* Special categories of cited documents :

- *A* document defining the general state of the art which is not considered to be of particular relevance
- *E* earlier document but published on or after the international filing date
- *L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- *O* document referring to an oral disclosure, use, exhibition or other means
- *P* document published prior to the international filing date but later than the priority date claimed

T later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

X document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

Y document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

& document member of the same patent family

Date of the actual completion of the international search

4 November 1994

Date of mailing of the international search report

14. 11. 94

Name and mailing address of the ISA

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Authorized officer

English, R

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 94/09139

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
Although claims 15-20 are directed to a method of treatment of the human/
animal body, the search has been carried out and based on the alleged
effects of the compound/composition.
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such
an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all
searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment
of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report
covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is
restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
- ☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US 94/09139

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP-A-0264795	27-04-88	DE-A- 3635907	28-04-88
		AU-A- 7982387	28-04-88
		JP-A- 63112548	17-05-88
		ZA-A- 8707950	26-04-88
EP-A-0468641	29-01-92	AU-B- 4489093	25-11-93
		AU-B- 643036	04-11-93
		AU-A- 7930491	02-01-92
		CA-A- 2045008	29-12-91
		JP-A- 5009162	19-01-93
		US-A- 5194608	16-03-93
		US-A- 5272268	21-12-93
		US-A- 5223615	29-06-93
WO-A-9404492	03-03-94	AU-B- 5347494	15-03-94